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Discharge produced in a vacuum chamber of 320 liters capacity with a magnetized spherical cathode of 2.5 centimeters (1 inch) diameter.

The Origin of Worlds—I*

The Evolution of Solar Systems Illustrated by Laboratory Experiments

By Prof. Kristian Birkeland

A LARGE number of experiments, made for the purpose of studying the similarity between the zodiacal light and the rings of Saturn,[1] have led me to discoveries which would seem to be of fundamental importance in understanding solar phenomena and the evolution of all celestial bodies in the universe.

In order to carry out these experiments, I studied the action of electric discharges under different conditions. In these experiments a magnetic globe in a large vessel exhausted of air served as a cathode. The larger the scale on which the experiments were conducted, the more interesting were the phenomena obtained. In carrying out my experiments, I used a vessel having a capacity of approximately 1,000 liters and a magnetic cathode-globe of 36 centimeters diameter, representing the sun. I employed a discharge that reached as much as four hundred milliamperes.

THE SUN.

I will begin my comparisons between cosmic phenomena and my experimental analogues by explaining the series of experiments represented in Fig. 3, *a*, *b*, *c*, *d*.

Small white spots will be noticed on the cathode-globe. These are due to electric discharges, which, as a general rule, are disruptive and emanate from these different spots on the globe. If the surface of this globe is perfectly smooth, the disruptive discharges will succeed one another with a rapidity that increases with the strength of the current employed. If the globe is not magnetic, the discharge spots will be distributed over the globe more or less uniformly, as shown in Fig. 3*a*. On the other hand, if the cathode-globe be magnetized, even only feebly, the spots will arrange themselves in two zones parallel to the magnetic equator of the globe; and the more the globe is magnetized the more the spot zones will approach the equator.[3]

The results obtained successively by Swabe, Wolf, Carrington and Spoerer have taught us that sun spots are definitely distributed in two zones between the fifth and fortieth degrees of north and south latitude, in such a manner that during a sun spot minimum, the spots begin to appear first in high latitudes and then descend successively to low latitudes, until they attain, at about the sun spot maximum, latitude 16 degrees north and south.

Bearing in mind what I clearly set forth as early as 1899[4], namely, that sun spots are really centers of emission for well-defined bundles of very hard cathode rays, producing auroras and magnetic perturbations on our earth, it would seem, from the analogies previously indicated, that sun spots may be the very emission centers

(*Continued on page 8.*)

* Paper read before the Academy of Sciences at Kristiania, on January 31st, 1913, constituting a review and an amplification of a series of notes that appeared in the Comptes Rendus de l'Académie des Sciences, Paris.

[1] Sur la Lumière Zodiacale. Comptes Rendus, February 6th, 1911. Les Anneaux de Saturne, sont-ils dus a une radiation electrique de la planète. Comptes Rendus, August 7th, 1911.

[3] Le Soleil et ses Taches. Comptes Rendus, August 21st, 1911.

[4] Recherches sur les Taches du Soleil et leur Origine, p. 167, Kristiania, 1900.

The Life Hazard in Crowded Buildings Due to Inadequate Exits*

Faults Exposed and Remedies Suggested

By H. F. J. Porter

Buildings in general are either non-fireproof or fireproof. The former can be compared to a pile of kindling wood out in the open, sometimes oil soaked and always ready to be set on fire. The latter are comparable to a stove full of fuel ready to be set on fire. In both cases the human occupants swarm around in the interstices in the pile of fuel, and as soon as the fire starts those caught in the fagots have to work their way down through the smoke and flames to the ground to save their lives.

Factory buildings in particular are sources of great danger to their large number of occupants, both on account of their non-fireproof construction and because of the obstructions to rapid egress, due to haphazard placing of machinery, furniture and partitions and the small number, size and character of these exit facilities.

Of late, there has been advocated the unrestricted use of fireproof construction in the buildings themselves and the author has recommended the development of a form of exit drill of the occupants of each building to determine if, in the case of danger, they could escape readily from the building and if they could not, the alteration of the exits until they could. By "readily" is meant within three minutes, for from many conferences it was found that people do not want, nor would it be safe, to remain in a burning building longer than that time.

The capacity of a stairway, if time is not a factor and a stream of people pours into it only at the top and out of it from the bottom, is unlimited; but if time is to be considered the capacity is limited by its cross-sectional area. In a multi-storied building with crowds of people on each floor trying at different points in its length to get on to one stairway in a limited time, the conditions are very different. If more people try to get on to the stairs from each floor than the section between that floor and the floor below will hold, a jam will occur so that the flow downward will cease. The capacity of this section is very limited.

A crowd of people does not flow like a liquid composed of round smooth molecules. Their soft bodies are angular in shape more like pieces of rubber with wires in them and they therefore interlock. Clothes present rough surfaces causing friction and if the stairway is narrow an arch is apt to form across it which can become an obstruction in case of pressure from above such as actually o burst the stair rail or inclosing partition.

The capacity of a stairway of the average height of from 10 to 12 feet between floors and not less than 22 inches wide would be one person on every other step or 10 and 12 per floor respectively, and if the width is doubled (not less than 44 inches) so that two people can come down abreast, twice those numbers or 20 and 24. If a stairway has winders in it, its capacity is reduced 50 per cent. One person can descend a single flight of such steps 10 to 12 feet high in 10 seconds, striking a gait which he can maintain for seven or eight flights of steps. After that he goes slower, making the tenth flights in about 11 or 12 seconds. Every person added in single file adds 1 second to this time. A double file takes no longer if the stairs are double width. Thus it will take 10 seconds for 10 or 20 people, that is, the full capacity of a flight of steps, to come down one story. The capacity of a stairway may be thus increased by widening it in multiples of 22 inches. A crowd of people cannot be depended upon to come down more than ten stories. One or more of them will give out, and demand the attention of others. Those who do get down will be severely taxed. The total time required to empty a building is determined by the time required to empty either the floor farthest from the ground or the floor occupied by the greatest number of people.

FORMULA FOR EMPTYING A FLOOR BY ONE STAIRWAY.

Number of couples (number of people divided by 2) . . . c
Time of formation in line after signal, seconds 10
Time one couple takes to march to top of stairs, seconds 10
Time each couple takes to pass through door at top of stairs, seconds 1
Number of stair flights (one less than number of floors) . f
Time of one couple to descend one flight of stairs, seconds 10
Time of one couple to go from foot of stairs to street, seconds 10

Total time $= T = 30 + c1 + f10$

Example.—Time of emptying 100 people from tenth floor.

$T = 30 + 50 + 90 = 170$ seconds $= 2$ minutes, 50 seconds.

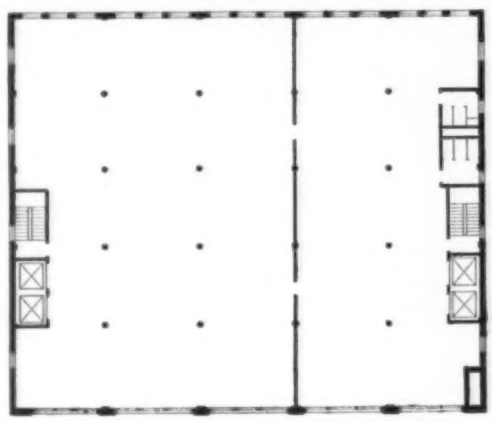


Fig. 1.—Floor plan of typical loft building showing fire wall with doorways.

Example.—Time of emptying a ten-story building with 20 people on each floor is the same as emptying 20 people from tenth floor.

$T = 30 + 10 + 90 = 130 = 2$ minutes, 10 seconds.

Tests of the capacity of fire escapes in a limited time gave the following results: A straight ladder, 2 per floor; ladder set at 50 to 60 degrees with the horizontal requiring people to go down backwards 3 to 4 per floor; stairs 30 inches wide, 10 to 12 per floor; and the modern outside stairway with a mezzanine platform 40 inches wide, 20 to 24 per floor, the same as an inside stairway. Fire escapes are usually so exposed to flames from windows opening upon them that they are more often fire traps than fire escapes. They should be prohibited by law and safer methods of escape provided.

In order to insure the safety of the occupants of a building in case of emergency one of two things has to be done: (*a*) there should be two stairways so that if one is cut off by flames or smoke the other can be used and the number of occupants reduced on each floor to meet the limited capacity of the part of the stairway between floors, or (*b*) the number of stairways increased so as to have two separate and independent stairways from each floor to the ground with its own exit from the building. People can then pour into the top whichever one is not cut off by the fire and continue down and out at the bottom without colliding with those from any other floor. Fire drills installed under either of these conditions worked more or less satisfactorily, and the author tried unsuccessfully for years to have ordinances passed in New York city and legislation enacted at Albany, making them mandatory, but the expense of changes in the buildings and the idea of having employees walk out of a factory while manufacturing operations were under way, upon the sounding of an unexpected signal, did not appeal to factory proprietors as practical. It required holocausts in New Jersey, Pennsylvania and New York finally to bring about the legislation in those States.

As time passed, however, the author developed what might be termed an exit test in factories which presented the opportunity and found to his astonishment that almost without exception, exit facilities adequate for handling the regular number of occupants under emergency conditions, were lacking.

This situation has probably developed with the rapid growth of industry where a factory building had been built to accommodate a certain number of people, and then, as the business grew, more people were accommodated without realizing that each additional person became an increment of danger to all. Or, if the danger was at all appreciated, some means of escape from windows was supplied which might be anything from a rope to a ladder. After this condition had become general it crystallized into custom, and new buildings with exit facilities inadequate for their occupancy were designed, erected and accepted as safe. Ropes were followed by ladders, and these in turn by fire escapes which became in time an established necessity.

Engineers, when called upon to supply a mechanism, are expected to have it subjected to a working test, which it must pass before they get paid for it; but architects and builders have never been called upon to demonstrate by actual test that the facilities which they have supplied in their buildings for the purpose of emptying them under emergency conditions will actually work, and this notwithstanding repeated instances of panic congestion on stairs, of people being burned to death on fire escapes, of elevators sticking from the warping of their runways from heat, etc.

When subjected to test these exit facilities in many buildings have been found to be entirely wanting in adequacy, and when this fact was brought to the attention of those who were responsible, it has been surprising to find how readily they accepted the criticism. On the other hand, those who possess these unemptiable buildings are skeptical of such statements and unwilling to be persuaded that the buildings are not safe. They point to all the other buildings erected by reputable architects and builders and naturally are incredulous.

In order to empty these buildings, additional stairways had to be built and fire drills developed to take the people out. Such changes in the building are expensive, for two stairways have to be installed from each floor to ground, so that if one is cut off by a fire, the other can be used. In many-storied buildings the number of stairways required becomes impractical. In addition fire drills are expensive to operate, for they involve not only loss of time of operatives and a break in the continuity of the process of manufacture, but the actual going down stairs and return of people, some of whom may be lame, others affected by weak hearts or lungs, others anaemic or organically weak, reduce the efficiency of the working force for a very appreciable time. If the drill takes place at the end of the day this criticism might be modified slightly.

Such is the situation in the usual type of factory building to be found in the average town where ground is cheap, buildings large and stairways broad. Turning now to the loft building used for factory purposes, the conditions as regards emptiability are found to be very much worse and have to be corrected in a different manner.

Let us consider for the moment a one-story or ground-floor factory building with a doorway at each side, one of which is cut off by a fire. The people can march out horizontally through the other doorway and nothing will impede this horizontal exit except the size of the doorway. If this is 22 inches wide, a single file of people can pass out in an orderly manner at the rate of one person every second. If it is 44 inches wide, a line of people two abreast can pass out in the same time. One hundred people can make their exit through one 44-inch door, therefore, in 50 seconds, or say one minute.

Now put another factory on top of this one with one hundred people in it. The doorway at each side will have to open on stairways which lead down to the doorways constituting the exits from the factory below. Suppose a fire occurs on the floor below, cutting off one of these exits, the 100 people on the lower floor immediately proceed to make their horizontal exit, while those on the upper floor proceed to make a vertical downward exit to reach the doorway out of which those below are moving. The result is of course a collision, the stream of people from upstairs coming down upon the stream of people on the ground floor on their way out. This collision prevents both the up-stairs stream from coming down and the down-stairs stream from going out. There is a complete lock, and the building does not empty.

Not only have we put one factory on another in the case of our loft building, but we have piled factory on

* Paper read before The American Society of Mechanical Engineers, and published in its *Transactions*.

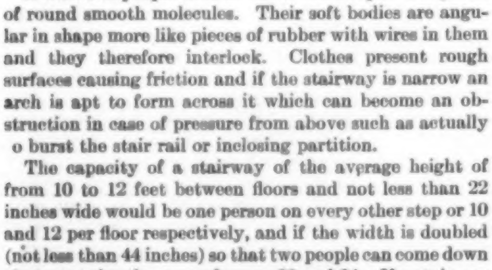


Fig. 2.—Department store floor plan showing present arrangement of fire walls, elevators and stairs.

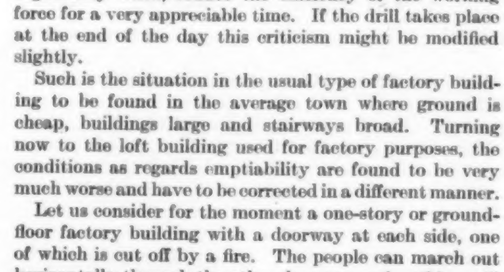


Fig. 3.—Suggested arrangement of fire walls, elevators and stairs for department store.

factory until we have from 10 to 30 and more, one on top of the other; and each employing from 100 to 300 or more people. In cases of emergency as in the Asch Building fire, there are only two courses for the occupants: one is to burn to death, and the other to jump to death—"to burn up or jump down."

It is impossible to reduce the number of people per floor to the capacity of the stairs, say 24 per floor. Even if that number were all that a business required, in case of emergency they would have to go down stairs, and it is a physical impossibility for people to stand the exertion of a trip down more than ten stories without resting; and when they stop to rest they block the stream and obstruct its exit. Under these circumstances it is necessary to develop some other method for people in high buildings to secure safety. The following suggestion is offered to meet the situation:

It has been seen that a horizontal escape by people on the ground floor is readily secured. Let us see if a horizontal escape to safety for people at any height from the ground can be developed. Suppose a wall is built across the building from cellar to roof practically bisecting it in a way so as to have a stairway and elevator on each side. This wall should have at least two doorways in it at a considerable distance from each other and closed by self-closing fireproof doors (Fig. 1).

It is improbable that a fire will occur on both sides of this wall simultaneously. It could occur only by incendiary origin, and that would hardly be possible in working hours. Should one occur on either side, the people on that side would go through the doorways in the fire wall, close the doors after them and be perfectly safe. That half of the building in which the fire might be should be emptied in less than a minute if there were no more than 100 people on each floor to pass through one doorway 44 inches wide. If the principle of the horizontal escape presented by the fire wall is included in the design of new buildings a most satisfactory method of securing safety at comparatively small expense will be offered.

In every way possible the horizontal escape should be developed in old buildings and the vertical escape subordinated. Factory buildings adjoining one another may have doorways through their sides connecting them on various floors closed by fireproof self-closing doors, or may be connected by outside balconies built around the party walls; or, if of different heights, doors in the sides of one may lead out on the roofs of the others.

The fire wall bisecting the building as described makes practically two buildings, each provided with elevators and stairways. A fire on one side of the wall would be confined to half the building, and therefore the property loss would be reduced one half. Only one half the people would be endangered and have to move, and the distance they would have to go would be only one half what it would be if they were on the ground floor of a building without a fire wall. They could remain on the same floor 'till the fire was extinguished, or could go down to the ground by the elevators operating under normal conditions.

The fire wall eliminates the necessity for a fire drill with its accompanying objections. Of course all buildings occupied by many people should have a fire alarm signal system in them to advise the people promptly of their danger. In buildings where there is a fire wall the signals should be arranged so that in case a fire should occur on one side of the fire wall on any floor, a bell on each floor on the same side of the fire wall would ring, indicating on which floor the fire is. Then all the people on that floor and above it should pass through the fire wall and close the doors. Those below need not disturb themselves until the fire threatens them, and then they too can pass through the fire wall.

There are certain other safety devices which should be supplied in factories to protect the lives of the operatives from fire. One of these is metal-framed windows with wire glass. These are made so as to close automatically in case of fire, thus preventing the latter from spreading upward from floor to floor outside of the building.

Another safety device is automatic sprinklers which serve to extinguish fires in their incipiency. All doors should be made to swing outward, and where they open on a hall or stair landing they should be vestibuled, so as not to obstruct the passage way. Sliding doors should be avoided if possible, as they are apt to stick or jam by pressure of people upon them.

Each floor of our typical loft buildings is, say, 100 feet by 100 feet by 10 feet and therefore contains 100,000 cubic feet of air. The laws of New York and many other states require 250 cubic feet of air per person as a limitation of occupancy. This limits the number of people per floor in a building of this size to 400 and if the stairways were 44 inches wide (and there are none now over 36 inches)at most only 40 per floor could possibly go down them even if the other 360 would let them.

With the fire wall only 200 of the 400 people on each floor would have to move, and if there were two doorways in the fire wall at some distance from each other, they could reach safety through them in one minute, or if one were cut off by the fire, all could pass through the other easily in two minutes. More doorways can be introduced, and thus the time of exit could be lowered still further.

An effort is being made to increase the amount of air space required per person from 250 to 500 cubic feet, which would reduce the number of people per floor to 200, of whom only 100 would have to move, and they could easily reach safety in one minute.

The stairways and elevators should be inclosed in fireproof walls to prevent a fire on one floor continuing upward and setting the other floors on fire. The ceiling of the basement where the machinery is located should be fireproof, and should not be pierced inside of the building, so that a fire there would not reach the elevator shafts.

Fire escapes which are simple stairs and possess dangerous features not only of limitations as to size, but of accessibility for flames and smoke, should be looked upon as evidence of the incompetence or ignorance, or worse, of the architect, builder, or owner, and prohibited by law under a heavy fine. They are not only dangerous to life by giving a false confidence in their adequacy for escape, but they destroy the appearance of the building. Our cities should be built without such architectural blemishes.

Fire escapes of the chute type are tubes with a smooth helix instead of steps. If the only opening is at the top they have considerable capacity. They soon rust, however, and at best are not to be considered seriously in comparison with other means of safe exit. People cannot enter them at different floors while a stream of people is passing down from above.

The smoke-proof tower, claimed to have originated in Philadelphia, is the latest improvement in the line of fire escapes. It is simply an inclosed stairway on the outside of a building, but cannot be reached except by going out of doors. Its special claim is that smoke and flames cannot get into it. It has, however, no more capacity than any other stairway, and as its approach is always open to the weather and its interior is always more or less dark, it is never used in ordinary service and becomes neglected. These monuments to architectural incompetency can be seen here and there filled with the dust and accumulated rubbish of every unused open space. When a time arrives for using them everybody has forgotten their existence. During the last year or two, notwithstanding the protests of many, a great many new buildings have been constructed, especially in New York city, with these monstrosities on them, and have been accepted by the Building Department in all seriousness.

The fire wall should be introduced into all buildings where the public congregates in large numbers. Large department stores, which on certain days are said to accommodate several thousand people per floor, are very dangerous places at present. A fire, or a panic without a fire, might cause a fearful tragedy. It is criminal for their owners to object to fire walls and offer as an excuse that they would obstruct the vista. Certain cities require fire walls in such buildings now as a property protection, and the vista is dispensed with without comment. The department stores of Philadelphia are so divided; John Wanamaker's new store there is divided by two such walls as shown in Fig. 2. The exit facilities in it, however, are badly arranged, for the architect apparently did not think of the life hazard of its occupants, and designed the fire walls to protect property only. Fig. 3 shows how the building might be redesigned so as to be safer. It should be noted that the elevators are removed from the fire wall so that people trying to go down in them would not block the doorways of the fire wall and prevent others coming through them. The stairways are situated as far from the fire wall as possible and should be inclosed by fire proof partitions.

Churches, assembly halls and similar ground-floor buildings should have their floor fireproof and unpierced so that any fire occurring in the basement would not endanger the occupants of the main building.

Moving picture buildings, theaters, etc., should be redesigned (Fig. 4). People come out of them by the way they go in, and in case of emergency all crowd into the narrow aisles. These aisles should be turned across the room and lead directly to courts opening on the street in a way such that streams of people will not collide. The various balconies and galleries should have foyers behind fire walls with separate stairs and street exits so that patrons will not have to mingle with those making their exit from the lower floors.

Every school building should be divided by a fire wall providing a horizontal exit on each floor, so that the children will not have to be drilled to go down stairs in case of fire.

Hospitals where the inmates are bedridden, blind, lame, invalid, imbecile, or otherwise helpless, can be made safe by the introduction of the fire wall between wards, and in case of fire those who are bedridden can be wheeled on their beds through the doorways, and those who are up and about can walk through them.

Hotels and apartment buildings can so easily have a fire wall developed in them that it need only be referred to here in passing. Even the private residence where only a few people occupy a floor can be made safe in this way. The back stairway should be inclosed in a fireproof partition, and in case of a fire instead of everybody having to go down stairs through the smoke and flames, or having to jump from windows, the people on each floor have simply to pass through the fireproof door and go down stairs in safety. In large residences where there is a servants' quarters in connection with the back stairs, the building would be bisected and the people on either side of the wall would be able to carry their clothing and perhaps much household and personal property to safety.

The Earth's Continental Pole

M. Alphonse Berget, Professor at the Oceanographic Institute, has just made a series of very interesting studies in order to find the position of the Continental pole of the earth.

If we take for the pole a little French island, the Isle of Dumet, situated near the mouth of the river Vilaine, we can trace a large circle, which divides the earth into two hemispheres in such a way that one contains almost the totality of continents, 45.5 per cent land and 54.5 per cent water; that is the *Continental hemisphere*, whereas the other, the *Oceanic hemisphere*, contains 88.7 per cent water and only 11.3 per cent of emerging land.

So, then, the Isle of Dumet, according to the successive trials and precise measurements of Prof. Berget, is the Continental pole of the earth. Any other point gives two hemispheres, of which the differentiation between terrestrial and marine domains is less marked.—*Chemical News.*

A Rubens' Picture Identified by Photography

Prof. Lippmann announced, a short while ago, that photography had been able to reproduce the traces that had become invisible to the naked eye, of retouchings made by Raphael on a certain number of his drawings.

By the use of a similar process, and by projecting a cone of ultra-violet rays on a picture attributed to Rubens, M. Parenty, Chief Engineer of the State Manufactories of Lille, has been able to identify the work of the great master.

This picture of the Museum of Lille is a decollation of St. John the Baptist, which was marked as attributed to Rubens. M. Parenty, on a photographic negative of this picture, has been able to show up very distinctly the authentic signature of the illustrious master. This signature having become completely invisible, had up till now not been discerned by connoisseurs.—*Chemical News.*

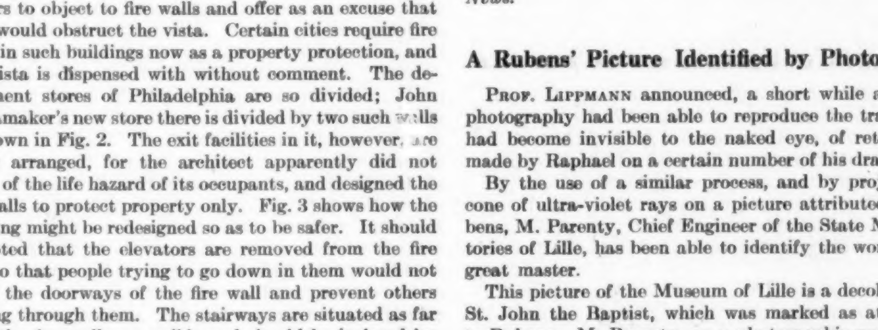


Fig. 4.—Typical and proposed theater plan showing use of fire walls, side entrances and exits.

Fig. 1.—350 horse-power marine Diesel engine. Perspective view.

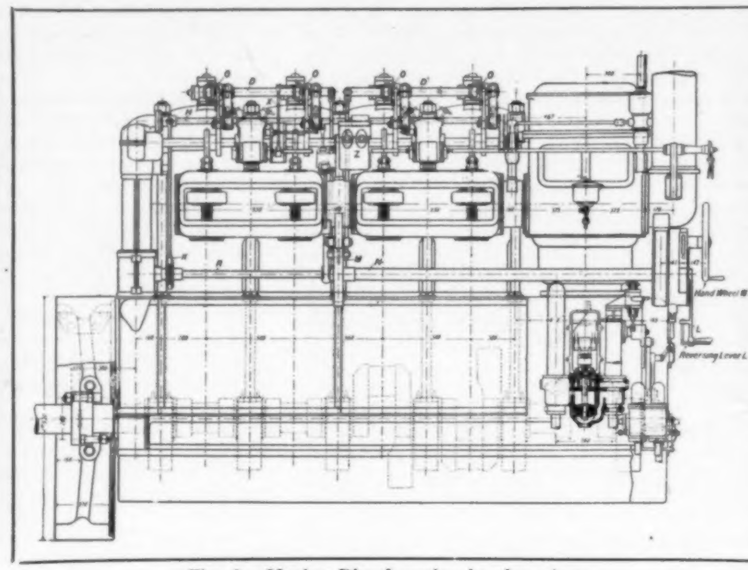


Fig. 2.—Marine Diesel engine in plan view.

A French Diesel Engine*

At the works of the Forges et Chantiers de la Mediterranée at Le Havre the usual Sulzer construction of the cylinders and framing has been followed, with separate cover and with the steel columns extending from the top of the cover right through to the bed-plate, so as to relieve the cylinder casting of longitudinal stresses. This in the Sulzer arrangement is especially desirable owing to the two rows of ports round the liner for exhaust and scavenge, which would probably render it positively unsafe to trust to the cylinder for longitudinal strength. Another fact which results from these steel columns extended right down from the top of the cover is that all the expansion of the cylinder and cover must take place downward toward the shaft, so that it cannot affect the clearances or the valve setting. It should be said here, by the way, that the drawings illustrating this article are to some extent diagrammatic and should not be taken as representing either the scale or the methods of construction actually adopted in all cases, but they serve to show the principles of working of the various parts. As the engines are designed for work on submarines, the limitations in the head room necessitate the use of trunk pistons, which have been adopted in this case. The scavenge pump is driven off its own crank pin at the forward end of the engine and the valves are automatic, so that the link reversing gear by which we were so much struck on the "Monte Penedo" is missing, and no means of reversing are necessary; the same holds good of the three-stage compressor, which is driven by the usual Sulzer balance arrangement. The scavenge air enters through two rows of ports at the bottom of the cylinder, the lower row being controlled by the passage of the piston, the upper row by a valve in the air pipe operated by a cam on the cam shaft. This double row of ports allows the scavenge to begin after the exhaust has released the greater part of the pressure in the cylinder, and to continue after the exhaust ports are closed by the passage of the piston, so that a full charge of air is intrapped by the piston on its upward stroke for compression. This method of port scavenging in place of what might be termed valve scavenging has apparently been found to be satisfactory, though a great deal depends on the careful and accurate shaping of the ports, which cannot be gathered from the drawing. The great merit, in our opinion, is that by allowing the valves to be removed from the covers the number of holes in the cover is reduced, so that a point which constitutes one of the greatest sources of weakness in a Diesel engine is eliminated. The pumps for circulating the water through the jackets and the pistons and the bilge pump are all driven by levers off the scavenge pump connecting-rod.

Now let us come to the reversing gear, which always forms the *piece de resistance* in descriptions of the modern Diesel engine. Although it is a Sulzer engine of which most details are Messrs. Sulzer's own design, we shall not attempt to discriminate between the original features and those which have been introduced by the Forges et Chantiers, but shall treat the whole as being the Forges et Chantiers' design. First, let us take the well-known point of the part rotation of the cam shaft in relation to the crank shaft to give the setting of the cams for reverse direction of rotation of the engines. As is well known, the fuel valve opens some 7 degrees before the top dead center and closes some 32 degrees past the top center, as shown in the diagram (Fig. 3) so that if the cam shaft is rotated backward through 25 degrees its setting will then be correct for the opposite direction of rotation as far as the fuel valves are concerned. Unfortunately, however, the scavenge valves, which are operated from the same cam shaft, require a greater range of movement, amounting to some 41 degrees, so that if the cam shaft is rotated to suit one it would not suit the other. The Forges et Chantiers, therefore, rotate the cam

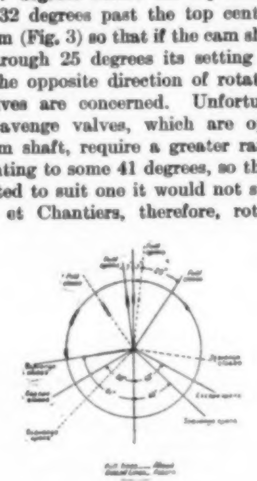


Fig. 3

shaft so as to suit the scavenge valves and alter the setting of the fuel valves independently by an arrangement which is also used to vary the amount of opening of the fuel valves to regulate the injection of the fuel. This arrangement allows of a variation in the time of opening of the fuel valve of from 5 to 16 per cent of the stroke after the top center, with corresponding increase in the lift of the valve. The maximum in each case is, of course, used for the highest speeds, though it also helps in cases where specially heavy oils are being employed; a still further means of adjustment can be obtained by varying the pressure of the injection air, so that the range is very considerable. This variation in setting is effected by holding the foot of the link *A* (Fig. 5), which suspends the fuel valve roller from its rocker *B* by a short link *C* on a short arm on the shaft *H*, so that it can be swung across the center line of the cam shaft, which has the same effect as if the cam shaft itself had been rotated to a lesser degree. Now that this is made clear the operation of reversing can the more easily be followed. There are two operations necessary to reverse; the first is to shift the reversing lever *L* (Fig. 2) from neutral into the ahead position; this alters the relationship

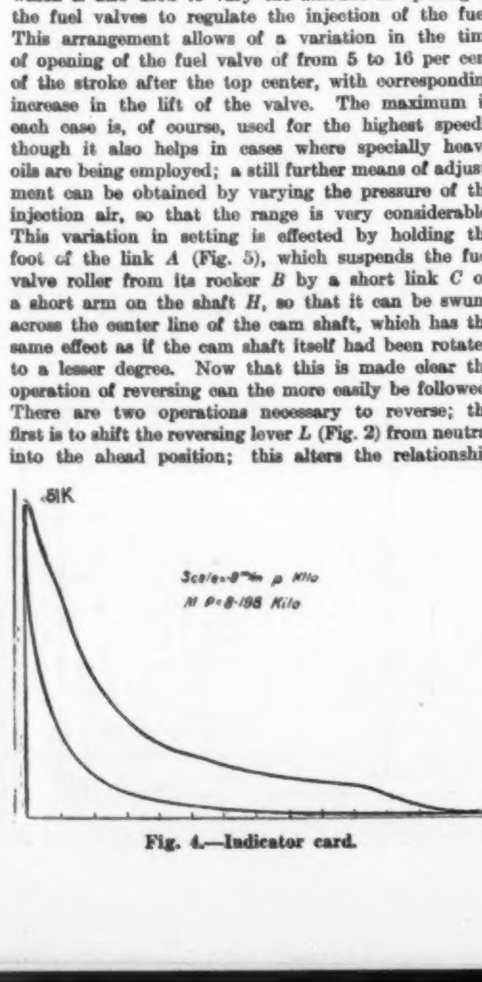


Fig. 4.—Indicator card.

of the cam shaft to the crank shaft, as has been mentioned, not, however, by the usual method of lifting the vertical driving spindle in the skew gearing; but here the vertical spindle is in two pieces connected together by a sleeve *E* (Fig. 5). The lower part of the vertical spindle has a pin *F* in it, which slides in a vertical slot in the sleeve, while the other part has a corresponding pin *G*, which slides in a slot cut diagonally in the sleeve. The reversing lever, then, through the shaft *R* and the lever *P*, simply lifts the sleeve *E*, which has no effect on the lower part of the spindle, but the diagonal slot in the upper part causes the part to revolve slightly relatively to the lower one; thus, the work required to be done by the lever is less than if the spindle itself had to be lifted, and the movement of the lever entails very little labor. When the two shafts are in their correct relative positions a pin *S* on an arm on the end of the shaft *R* passes beyond the slot *T* in the lever *P*, so that continued movement of the reversing lever has no further effect on the sleeve, but it continues turning the small eccentric *K* (Fig. 5) which is connected to the shaft *H*, which carries the arm connected to the link *C* on the foot of the fuel valve link *A* mentioned above; this movement shifts the rollers sufficiently far across the center of the cam shaft to make up for the incorrect setting of their rollers, as already described. Now, the cams are set in their correct position for going ahead, but the fuel valve rollers are not in contact with their cams, the rockers of the fuel valve and starting air valves being mounted eccentrically to each other on shafts *D* D^1 (Fig. 2) in the usual manner, *D* being for one pair of cylinders and D^1 for the other pair. The next step, then, is to turn the hand wheel *W* (Fig. 2) from the stop position to that which puts the four cylinders on air. This is brought about by means of a disk *M* (Fig. 7) with two cam paths cut in it and mounted on a shaft *N* through which the shaft *R* runs; one of these cam paths is for the forward pair of cylinders and the other for the after pair of cylinders. The first position of the cam paths rotates the top shaft *D* and swings the fuel and air valve rockers over so that the rollers of the former come into contact with their cams, and it should be noted here that there are no rollers directly fitted on the air valve rockers, but in the position indicated, a pin *O* (Fig. 2) projecting from the end of the fuel valve rocker engages the air valve rocker and holds the air valve open all the time—it does not open and close in accordance with the requirements of the piston position. Air would therefore be free to enter the cylinder throughout the revolution if it were not for the existence of four little distributing valves *J* (Fig. 7) mounted in a casing *Z* level with the cam shaft. These distributing valves are operated by eight special little cams—four for ahead, four for astern—on a sliding block on the cam shaft, and this block can slide longitudinally so as to bring the correct cams in contact with their rollers for the desired direction of rotation; here, too, it should be noted that in order to put the distributing valves out of action and also to allow the cams to slide, the rollers must be lifted clear, and this is done through the usual eccentric mounting of the rockers by the movement of the hand wheel, which, acting under the direction of the cam paths, raises or lowers the lever *V* according to whether the rollers are required to be in contact or clear. Similarly, when the revers-

* Reproduced from the Engineer.

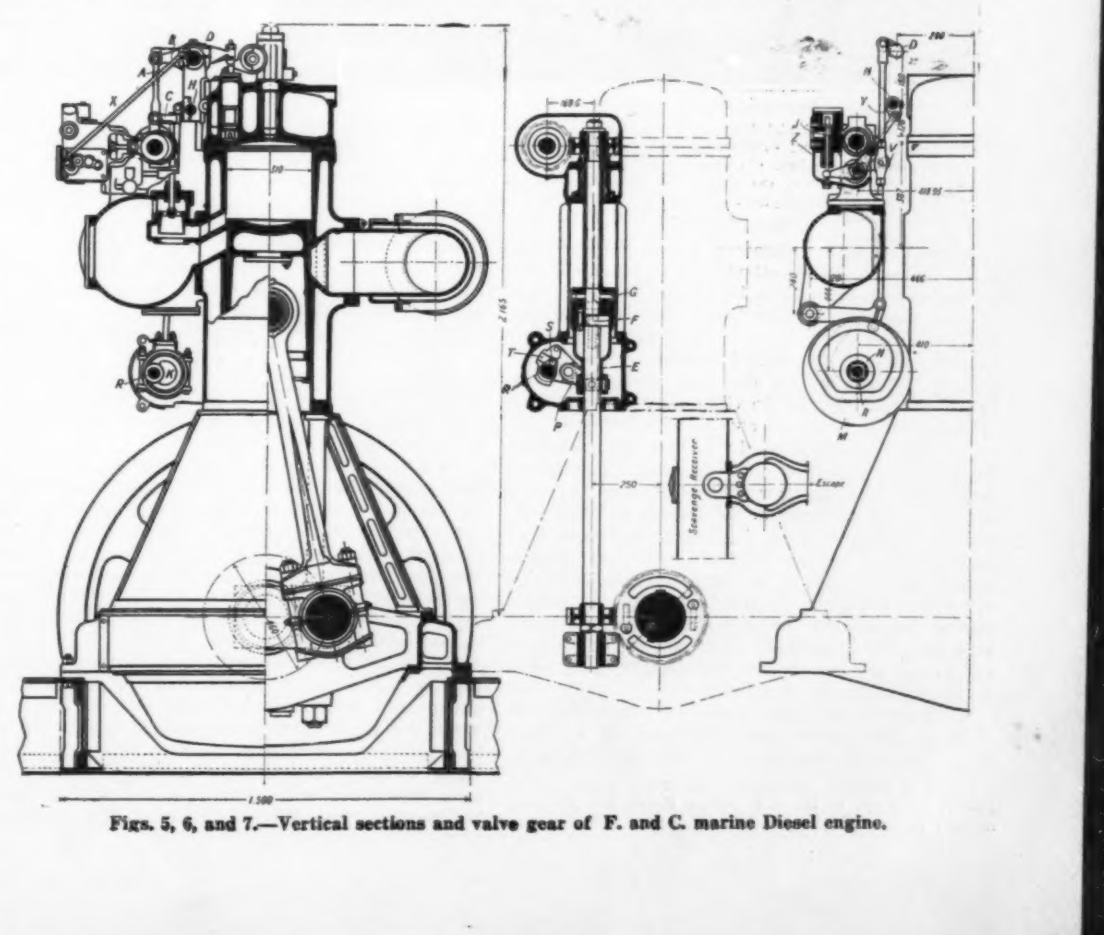
ing lever L is moved to ahead or astern position it not only alters the cam shaft to the required setting, but it also, through the lever Y and a wedge block connected to it, slides the cam block into the correct position to operate the air distributing valves for the required direction of rotation. There is a misleading appearance of simplicity in part of the above arrangement, in that the air valve rockers have no roller or link, though this is more than counterbalanced by the extra cam block and the distributing valves, that is, as far as appearance alone goes. But we must look further into this arrangement and see what has been the object of the designer before proceeding to criticise. Monsieur Bezin pointed out that the air starting valves, running as they do in the hot cylinder heads and being exposed to the hot gases, are liable to stick, or, at all events, to become leaky. The former would render the cylinder inoperative when starting up or when running, and under the latter conditions might lead to an accident owing to unconsumed fuel being blown back into the air bottles and exploding, while the leak in the valve would certainly lead to a reduction in compression and reduce efficiency. Furthermore, leakage of air past the starting valve would allow the accumulation of air in the cylinder at a pressure higher than that of the atmosphere so that the compression pressure would be increased greatly beyond the normal, and this has undoubtedly been the cause of accidents in the past, and the M.A.N., among others, have recognized the danger and provided against it in much the same way as the Forges et Chantiers. The existence of the distributing valves limits the amount of the leak to the contents of the air pipe and valve chest and absolutely prevents any fuel passing back into the air bottles. That is the first purpose of the designer; it is a safeguard, and as such it is valuable. Beyond this, however, when starting up, the whole volume of the starting valve chamber and the length of the pipe up to the distributing valve is added to the compression space, so that the compression pressure in the cylinder is reduced from 500 pounds to about 380 pounds per square inch, and the engine is much easier to start on air. It will, of course, be understood that if the main starting air valve were to leak it would hardly be likely to be a big enough leak to reduce the compression in the cylinder sufficiently to prevent combustion taking place. This reduction in compression is no doubt a fortuitous advantage, but it is a considerable one, so considerable, indeed, that in the Bukh engine a special valve and chamber are actually added to the engine to allow of this reduction in pressure when starting up on gasoline, which in that engine is used instead of air. Theoretically the Forges et Chantiers design is, however, a better one, in that existing parts are used, although in actual practice the Bukh engine would also have to have some such arrangement for air starting if it were not designed to be started on gasoline. At all events, we think that the additional expense and complication involved are well worth it in view of what they are designed to achieve.

Now to return to the movement of the hand wheel. In the first position both the cam paths of the disk coincide and shift the rockers of the fuel valves and air starting and distributing valves so that all four cylinders are on air and the engine starts up. The next movement of the wheel shifts the cam paths round into a position in which they do not coincide, and this results in turning the rockers of two of the cylinders to the previous or stop position, whereas the other two cylinders are put on to oil and the air is shut off so that the engine starts running with only two cylinders at work. This position is suitable for slow-speed running and no air is being wasted in the other two cylinders. The next movement of the wheel causes the two cam paths again to coincide and all four cylinders are on oil and the engine is at full speed; the next movement of the wheel brings the engine back into stop position; the reversing lever can then be turned to the neutral position if desired. It should particularly be noted that only when the wheel is in the stop position with the oil supply entirely shut off can the reversing lever be shifted at all between ahead and astern, so that the man in charge cannot possibly make the mistake of trying to stop his engine by the reversing lever. The lever can, however, be moved slightly beyond the ahead position or beyond the astern position whatever the position of the wheel, and this only affects the eccentric K on the same shaft, which, as we have said, swings the fuel rollers across the cam shaft center and so regulates the fuel injection. Thus, there is only one wheel and one lever to be operated. Put the lever ahead or astern as required, then turn the hand wheel almost continuously through its consecutive positions till all four cylinders are on oil and then adjust the fuel valve opening on the lever. If only a point to which we have before drawn attention did not arise, and the reversing lever were moved in a to-and-fro direction instead of across the body, we should have nothing but praise for an arrangement which is otherwise admirable. It is to be noted that for submarine work it is absolutely necessary for the reversing arrangements to be situated at one end on account of the lack of space athwartship.

In addition to the above arrangements for control there is a link X (Fig. 5) carried on an arm on the shaft D, and when this shaft is in the position to put the air starting valves in action the link X lifts the suction valves of the two fuel pumps of the cylinders concerned, that is, the two cylinders which are due to be put out of action when the hand wheel is moved into its second position. Thus, the oil cannot possibly reach and flood the fuel valves of these two cylinders, however long they may have to be running idly. There is no such fitting on the pumps of the other two cylinders, as they will never have to run for very long on air, but there is a small spindle below their suction valves which has two cams at an angle of 90 degrees to each other, and this spindle can be set by hand so as to put the suction valve of either of the pumps out of action if it is desired to have one of the cylinders inoperative for any reason. This also, in conjunction with the suction valve disengaging gear of the other two cylinders, allows of either one, two, or three cylinders being entirely put out of action, only one being left on duty if so desired, though we hardly think the result would be very satisfactory. Still it offers the possibility, and no doubt it is partly with this object that four separate fuel pumps are used instead of only one for all four cylinders. Then there is a centrifugal governor fitted on the cam shaft itself, a position which we cannot recall having seen before. It has the advantage that it puts the governor close to the suction valve which it is required to operate, and so a lot of links and levers are saved. The weights themselves, indeed, act directly on a curved lever, the other end of which operates the suction valve.

This practically exhausts the points of interest in connection with the valve gear, and we will now mention indiscriminately little points of interest that struck us in conversation with M. Bezin when examining the engine. For instance, we were rather interested by the impression which the Nuremburg accident has made upon the builders of these, and, in fact, of all, Diesel engines, even though that accident was the result of a most unfortunate and extraordinary concatenation of circumstances such as is not likely to recur. This impression was evidenced by the fitting of drain cocks in the scavenge air receiver piping, so that no oil can accumulate therein to furnish the basis for another explosion. The impression having manifested itself in this way, we were very much surprised to see that it had not gone to the extent of fitting relief valves also on this pipe, although big relief valves are now fitted in the latest pattern of Nuremburg engines, and, further, that relief valves were not even fitted on the cylinders themselves, though called for by the Bureau Veritas. Monsieur Bezin has a reason to advance for this omission, stating that unless the valves are of very large size the damage would be done before they could give the necessary relief, as pressure is developed almost instantaneously. There appears to us to be some foundation for this opinion, as we ourselves have been present when a cylinder cover was cracked by an excessive explosion pressure, in spite of the relief valves lifting with a terrific bang. Whether this be so or not, we do not like to criticise any arrangement which is a matter of opinion and which is the result of due deliberation, even though the conclusions come to may not agree with our own. In this design the internal pipe is arranged in the form of a jet so as to throw the water clear of the sliding surface of the pipes, and so far from any attempt being made to have the two tubes a close and water-tight fit in each other, they are quite slack, so that wear does not take place, while leakage is almost encouraged; very great care is, however, taken of that leakage, and by very carefully designed chambers and overflow pipes every drop is taken possession of and quietly directed to a place where it can do no harm, namely, into a funnel outside the crank case where it is under observation. M. Bezin informs us that not a drop of water ever gets into the inside of the crank case. A difficulty which we have had mentioned to us two or three times lately while in conversation with Diesel engine builders using trunk pistons is that of preventing an excess of oil from getting on to the walls of the cylinders, and here, to provide against this, not only are baffle plates fitted over the crank webs with a slot just wide enough to pass the connecting-rods, but a thin and flexible dished plate is fixed on the bottom of the piston, the turned-up edge of which being a good fit in the cylinder will act as a scraper ring, and this is found to do its work admirably. We note, too, that the oil service is supplied with a duplicate filter, the delivery being switched over from one to the other by a two-way cock, so that one can be cleaned out without stopping the engine; this is an obvious thing to do, and just becoming general practice.

We cannot help concluding with a few words about the experience of the makers with Diesel engine construction. For some years they have been considering the question, but it was only in July, 1911, that they began the construction of this their first engine, a four-cylinder, two-cycle, single-acting engine with cylinders 310 millimeters diameter by 460 millimeters stroke. Sulzer's furnished them with all the drawings and a considerable amount of information, and two draughtsmen went to Winterthur to pick up what they could. Construction was then begun and the whole of the work, including casting, machining, erecting, adjusting, and testing was carried out by the Forges et Chantiers in a total period of fourteen months. They would not be helped in overcoming their difficulties, on the ground that what they found out for themselves they would know very much better than what they would be able to pick up from watching strangers do the work. In spite of this the engines have run well on the bench and given 380 horse-power at 250 revolutions per minute with a mechanical efficiency of 76 per cent and a consumption of 0.495 pound



Figs. 5, 6, and 7.—Vertical sections and valve gear of F. and C. marine Diesel engine.

per brake horse-power. Then, almost, it would seem, by way of a jest, they tried the engine right out to see what she could really do, and the result was that for half an hour she took an average overload of 50 per cent and gave 550 brake horse-power at only 260 revolutions per minute, an increase of 10 beyond the normal speed. This somewhat remarkable result was achieved by piling up the injection air to a pressure of 75 kilogrammes per square centimeter, 1,066 pounds per square inch, and piling in the fuel, solar oil, till the maximum pressure as shown by the diagrams was 51 kilogrammes, 725 pounds per square inch (see Fig. 4), which gave a mean indicated pressure of 8.25 kilogrammes, 118 pounds per square inch, not quite so high, certainly, as on the Eavestone, but the conditions were probably a good deal more severe on account of the higher revolution speed. For this overload test the mechanical efficiency was found to have risen to 82 per cent, while the consumption was 0.550 pound per brake horse-power. This result is very creditable for a first engine, and it is hardly to be wondered at that the firm has now received orders for four sets of 900 brake horse-power engines for submarines for the French navy.

The Spectroscope in Organic Chemistry*

By J. J. Dobbie, D.Sc., F.R.S.

Somewhat more than half a century ago, while engaged, with the assistance of Faraday, in preparing experiments for a Friday evening discourse in this institution, Stokes observed that the spectrum of the electric light extended to five or six times the length of the visible spectrum when he employed prisms and lenses of quartz instead of glass. This extension occurs at the violet end of the spectrum, and consists of rays of high refrangibility, to which the eye is insensitive, but which can be made apparent by means of a fluorescent screen.

Fig. 1

1. Spark spectrum of nickel and iron. 2. The same, after the light has passed through quartz 10 millimeters thick. 3. Crown glass 0.13 millimeters thick. 4. Crown glass 0.33 millimeters thick. 5. Window glass 1.62 millimeters thick.

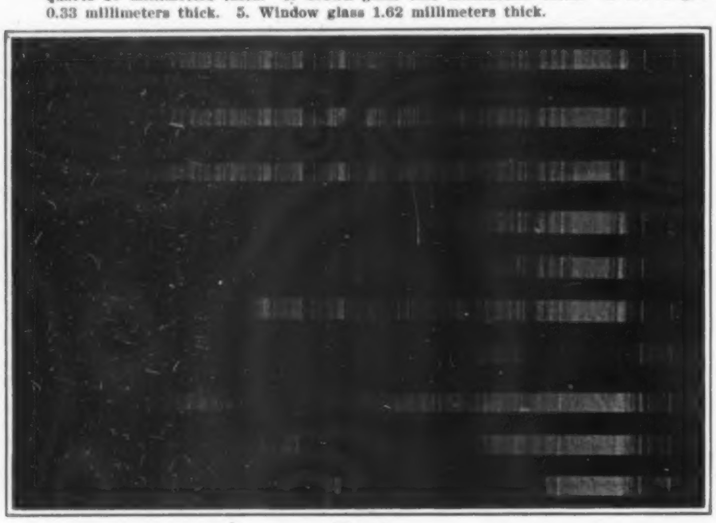


Fig. 2

1. Spark spectrum of nickel and iron. 2 and 3. The same after the light has passed through water and solution of cane sugar, respectively. Alcoholic solutions of (4) pinene, (5) thiophen, (6) citric acid illustrate general absorption, and alcoholic solutions of (7) isatin, (8) phenol (9) salicylic acid, (10) quinine hydrochloride illustrate selective absorption.

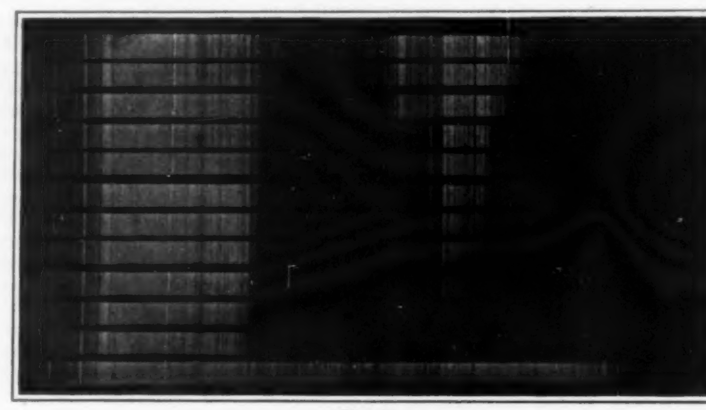


Fig. 3

1. Spark spectrum of nickel and iron. 2 to 12. The same after light has passed through layers of 0.001 normal solution of salicylic acid from 90 to 4 millimeters thick.

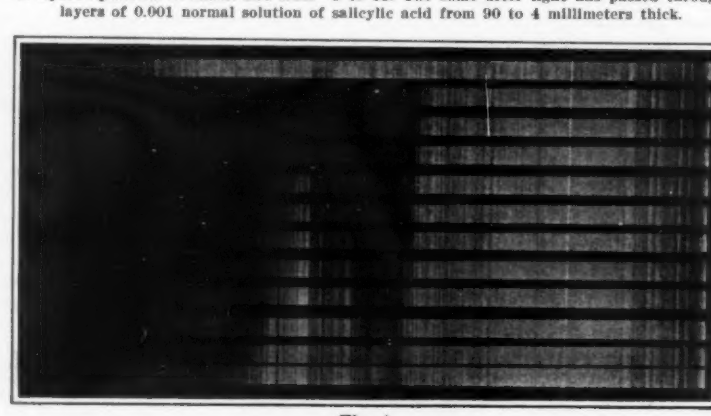


Fig. 4

1. Spark spectrum of nickel and iron. 2 to 12. The same after the light has passed through layers from 60 to 4 millimeters thick of an alcoholic solution of morphine containing 1/200 grain of the alkaloid. The spectroscopic test for alkaloids, such as morphine, strychnine and nicotine, rivals in delicacy the most refined color reactions known for the detection of these substances.

At the time of this discovery, and in the years immediately following it, attention was being directed to the absorption of light by colored solutions, and to the possibility of identifying colored substances by the number and position of the dark bands in the spectrum of light transmitted through their solutions. Stokes saw that by his discovery of the extension of the spectrum beyond the visible region, this method of investigation might be applied to colorless as well as to colored substances. In a paper communicated to the Royal Society in 1862, he says: "Having obtained the long spectrum above-mentioned, I could not fail to be interested in the manner in which substances, especially pure, but otherwise imperfectly known organic substances, might behave as to their absorption of the rays of high refrangibility." He proceeded, therefore, to study the action of various organic solutions on the ultra-violet rays, and found that the mode of absorption generally was so constant and so characteristic that by this single property many substances could be identified.

While Stokes was engaged in these researches, Prof. William Allen Miller was simultaneously at work in the same field, and Stokes left the further development of the subject in his hands. Miller improved the method of observation by substituting a photographic plate for the fluorescent screen, but he failed to "trace any special connection between the chemical complexity of a substance and its diactinic power." Struck by this fact, W. N. Hartley, now Sir Walter Hartley, commenced a systematic investigation of the whole subject, and it is to his researches, extending over a period of more than thirty years, that we owe, not only most of the knowledge which we now possess of the relation between the structure of organic substances and the action of such substances on the ultra-violet rays, but the elaboration of the convenient and elegant methods by which such investigations are now conducted.

The light derived from an ordinary source of illumination, such as an electric lamp, consists of waves of all degrees of refrangibility, and its spectrum shows a continuous band of color ranging from red to violet. The limits of this visible spectrum lie between the wave-lengths 7,600 and 3,900.

If, now, instead of the electric light or other ordinary source of illumination, we employ the light emitted by one of the metals when raised to a high temperature, the spectrum is seen to consist of a series of lines of different colors and intensities lying within the same limits as the visible spectrum. But there are rays beyond the red end of the spectrum and rays beyond the violet end which excite no sensation of luminosity in the eye. By allowing the spectrum to fall upon a screen which has been coated with a fluorescent substance, such as sulphate of quinine or a salt of uranium, these rays are rendered visible for a short distance beyond the violet. But it is only when we replace the glass apparatus, with which we have hitherto been working, by a quartz prism and lenses, and substitute a photographic plate for the eye, that the full extent of the spectrum beyond the violet is revealed. This is the ultra-violet region, the region which Stokes opened up to investigation, and it is with the behavior of organic substances toward the rays of this part of the spectrum that we have mainly to do this evening.

When light is transmitted through a colored solution certain rays are absorbed, and dark bands corresponding to these rays appear in the spectrum. The importance of these bands as a means of distinguishing colored substances has long been recognized, and, as we have already seen, considerable progress had been made with their study fifty years ago. As the bands in this case are in the visible spectrum, no special means are required for their observation.

But when we extend this method of investigation to colorless substances we are dealing with phenomena which lie hidden from the unaided eye, and our investigations are necessarily carried out with the help of photography.

The instrument employed in the study of absorption spectra consists of a spectroscope in which the eye piece of the telescope is replaced by a camera. The photographic plate is set at such an angle as to bring all the rays emanating from the source of light into focus at its surface after they have passed through the resolving prism, and for this purpose it is necessary that the plate should have a very slight curvature. The prisms and lenses of the apparatus are made of quartz, which, unlike glass, is readily permeable by the ultra-violet rays (Fig. 1). The source of light usually employed is that obtained by sparking one of the metals, such as iron, or a combination of metals, such as cadmium alloyed with lead and tin. In using the apparatus a photograph is first taken of the spectrum of the source of light. A layer of the substance to be examined, which, if a solid, must be dissolved in a suitable diactinic solvent, such as alcohol or water, is then interposed between the source of

* From a discourse delivered at the Royal Institution on Friday, April 4th, by Dr. J. J. Dobbie, F.R.S., and published in *Nature*.

light and the slit of the collimator, and another photograph is taken. By comparison of the two photographs it is seen what effect, if any, the substance has had upon the transmission of the light.

When organic substances are examined in this way it is found that some allow light to pass freely through them. Others shorten the spectrum by absorbing the rays at the ultra-violet end to a greater or less extent, and are said to show general absorption. Others, again, possess the remarkable property of absorbing rays of a particular wave-length, thereby producing gaps or bands in the spectrum; these are said to show selective absorption (Fig. 2).

In studying these phenomena in their relation to the chemical characters of a substance, it is of importance to determine not only the extent of the general absorption and the number and position of the absorption bands, but their degree of persistence, i. e., the range of concentration within which they are exhibited. It is necessary, therefore, to vary the concentration of the solution or the thickness of the layer so as to cover the whole phenomena of absorption. This is done by simply diluting the solution, or diminishing the thickness of layer, on one hand, until the entire spectrum is transmitted, and on the other by increasing the concentration or the thickness of the layer until no further characteristic absorptive effect is produced. Photographs are taken at each concentration, and a curve is drawn connecting the concentration and the absorption as measured with reference to the lines of the metal employed as a source of light (Fig. 3).

If we now inquire whether the substances which affect light in one or other of the different ways already indicated have themselves anything in common, we find that it is with those which possess the structure characteristic of benzene and its derivatives that the power of absorbing the rays of particular parts of the spectrum is most frequently, although not exclusively, associated.

Organic compounds, or compounds containing the element carbon, are divided into fatty or aliphatic, in which the carbon atoms are united in an open chain, and cyclic, in which the carbon atoms form a closed chain or ring. Hexane, which is a constituent of liquid paraffin, may be taken as an example of the first class. This substance possesses the formula C_6H_{14}. It is highly diactinic or transparent to the ultra-violet rays, and nearly all compounds belonging to the same division of organic chemistry, such as alcohols, sugars, and fatty acids, are either equally transparent to light, or only cut off a portion of the extreme ultra-violet rays of the spectrum.

If we now remove one atom of hydrogen from each of the two end carbon atoms of hexane, these atoms are in a condition to unite directly with each other, thus closing the chain. The substance so formed belongs to the cyclic division of organic compounds. It is known as cyclohexane, and has the formula C_6H_{12}, each carbon atom having two hydrogen atoms attached to it. This substance resembles hexane generally in its chemical properties, and behaves toward light in the same way, that is to say, it is practically diactinic or only cuts off some of the rays of light at the extreme ultra-violet end of the spectrum.

But a wholly different condition is brought about if we suppose one atom of hydrogen removed from each of the six carbon atoms of cyclohexane. One linkage is thus set free in each of the six carbon atoms, and we obtain benzene. How these linkages are actually employed in benzene has never been determined with certainty. Sometimes they are represented as mutually neutralizing one another, sometimes as effecting a double link between the alternate pairs of carbon atoms. However this may be, the structure which bears the relation that I have indicated to the structure of hexane and cyclohexane is characteristic of the large group of organic substances of which benzene is the type. It is to this division of the cyclic compounds that the great majority of substances which show selective absorption, i. e., produce breaks or dark bands in the spectrum, belong. Here, then, we have a very important and a very general relation between the structure of organic substances and their absorption spectra.

The difference in the behavior of organic bodies toward the ultra-violet rays, as exemplified in hexane and cyclohexane, on one hand, and benzene on the other, is brought out very clearly when we examine some of their derivatives. If we replace an atom of hydrogen in hexane or cyclohexane by the monovalent group hydroxyl, we get substances belonging to the class of alcohols, and these substances are, like their parent substances, highly diactinic. If, on the other hand, we replace an atom of hydrogen in benzene by the same group we get carbolic acid or phenol, which, like benzene, exercises selective absorption on the ultra-violet rays, but gives a spectrum widely different from that of benzene.

Having dealt with the most general relation that has been observed between the structure of organic substances and their action on the ultra-violet rays, I propose to illustrate some of the more special relations by examples from the phenomena of isomerism. By replacing an atom of hydrogen in carbolic acid or phenol by the nitro-group we obtain three distinct nitrophenols. The ultimate particles or molecules of these nitrophenols are all composed of the same elements, carbon, hydrogen, oxygen, and nitrogen, and of the same number of atoms of each element. Such substances are said to be isomeric, i. e., they are made up of equal parts, although they do not possess the same properties. The difference between them lies in the arrangement of the parts relatively to each other; in this case in the position of the nitro-group in relation to the hydroxyl group. On comparing the spectra of the three nitrophenols we find that they differ in quite a marked manner from one another, and afford an illustration of the important general rule that substances which have the same composition but different spectra differ in structure.

It will have been noticed that the substitution of the nitro-group for hydrogen in phenol has the effect of shifting the absorption band nearer to the visible region. One of the three nitrophenols has a yellow color, and in this case the gap in the spectrum cuts a little way into the violet end of the visible region. By the addition of soda to the solution the color is changed to red, and on examining the spectrum of this solution we see that the gap now extends far into the visible region. This example will serve to illustrate the close connection that exists between the study of absorption spectra and the origin of color, an interesting branch of the subject with which, however, it is impossible for me to deal within the limits of this discourse.

In the nitrophenols we have an example of what is known as structural isomerism, or position isomerism, because the phenomenon depends upon differences in the position or arrangement of the atoms within the molecule, in other words, in the internal structure of the molecule. But it is possible to have two substances of the same composition and structure not identical, but related to one another as an object is to its mirror-image. Substances so related are termed optical-isomers or stereo-isomers. The spectra of isomers of this class, unlike those of structural isomers, do not differ. This leads to an important application of absorption spectra in chemical investigations. If two substances have the same composition but different spectra, we know that they must be structurally different; if, on the other hand, they have the same composition and the same spectra, and yet are not identical, there is a strong probability although not a certainty, that they are optical-isomers.

The study of absorption spectra has proved of special value in the investigation of substances capable of existing in two forms which may pass the one into the other. It is rarely the case that both forms of such substances are stable, and it is often extremely difficult, or altogether impossible, on account of this instability, to determine by the ordinary chemical process which of the two possible forms the substance as we know it possesses. Such substances, however, frequently give rise to two series of stable isomeric methyl- or ethyl-derivatives, the structure of which can be ascertained by chemical investigation. The parent substance, if not a mixture of the two forms, must correspond in structure with one or other of these derivatives, because it is a well-established fact that the introduction of the methyl- or ethyl-group into a substance in place of an atom of hydrogen does not appreciably alter the spectrum.

An example of this is afforded by the three substances isatin, methyl-isatin, and methyl-pseudo-isatin. The structure of methyl-isatin and of methyl-pseudo-isatin has been determined by chemical methods, but the structure of the parent substance isatin cannot be determined in this way. Is it constituted like methyl-isatin or like methyl-pseudo-isatin? Inspection of the photographs of the spectra of the three substances shows that while there is a wide difference between the spectra of isatin and methyl-isatin, the spectra of isatin and methyl-pseudo-isatin are almost identical, as we should expect them to be on the view that they are constructed alike.

This phenomenon, which is known as tautomerism, is due to the fact that some substances contain an atom of hydrogen, or it may be a hydroxyl group, which readily shifts its position within the molecule, leaving its union with one atom to attach itself to another. Another example of this is afforded by cotarnine, a substance found in opium. The molecule of cotarnine possesses an atom of carbon which is directly combined with an atom of nitrogen, and has also united to it a hydroxyl group. Under the influence of certain reagents the hydroxyl group leaves the carbon atom and attaches itself to the nitrogen atom, but can readily, by an alteration of the conditions, be enticed back again to the carbon atom. The shifting of the position of the hydroxyl group is accompanied by other changes which, however, it is not necessary that we should take into account for our present purpose. In this case both the tautomeric forms are, under certain conditions, stable. The form in which the hydroxyl is attached to the carbon is colorless, while the form in which it is attached to the nitrogen is yellow. The two forms have totally distinct absorption spectra. When one of the forms passes into the other under the influence of the appropriate reagent, the amount of change is proportional to the quantity of reagent added. It is possible, therefore, by taking photographs after the addition of each successive quantity of reagent, to trace the progress of the change through all its phases, and to ascertain how much of each form is present at any time. This is done by comparison with a series of reference plates prepared by photographing mixtures in various definite proportions of two derivatives of cotarnine which possess the same spectra as the two parent forms.

The study of the absorption spectra of the alkaloids has been applied with success, not only to the investigation of their structure but to their detection and estimation. These substances generally have very characteristic spectra by means of which they can be distinguished with certainty from one another, except when they are homologous or otherwise very closely related structurally. The spectroscopic method may, therefore, be used with great advantage in examinations for the presence of alkaloids to confirm the results obtained by the usual chemical tests. The chemical tests are no doubt as a rule sufficiently distinctive, but considering the gravity of the circumstances in which they have frequently to be applied, it is unnecessary to insist on the value of the confirmatory evidence which can be obtained by the use of the spectroscope.

The minutest quantities of alkaloids can be detected by this means, the method rivaling the color reactions for the alkaloids in delicacy. Thus, with a quantity of strychnine not exceeding 1/500 of a grain, a clearly defined spectrum of the alkaloid can be obtained. The photograph of morphine already shown was obtained with 1/200 of a grain of the alkaloid, and that of nicotine with 1/100 (Fig. 4).

The use of the spectroscope in the detection and estimation of alkaloids in cases of poisoning possesses certain advantages of the highest importance. One is that the material is not destroyed. The solution which has been employed for the spectroscopic examination can be used afterward for the chemical examination. Another is that a permanent record is obtained which is always available for reference if occasion should arise.

So far my illustrations have been confined almost entirely to colorless substances, because it is in connection with the investigation of such substances that most of the recent advances in the subject have been made.

As my last example, I shall take the case of a colored substance in which the method has been applied within the last year with marked success.

It will be remembered that considerable uneasiness was caused when it became known some time ago that nitrogen peroxide is sometimes employed to bleach flour. In the course of an inquiry into the subject, it became necessary to determine the nature of the coloring matter naturally present in flour. It was known that many of the yellow and orange pigments so widely distributed throughout the vegetable kingdom are either closely connected or identical with carrotene, the orange coloring matter of carrots, and it had been suggested that the coloring matter of unbleached flour might be identical with, or belong to the same class of coloring matters as, this substance. It was impossible, however, to prove this by the usual chemical methods, because the amount of coloring matter in flour is so minute that its isolation in a pure state, and in sufficient quantity for chemical analysis, was scarcely practicable. Carrotene, however, can be prepared in a pure state, and the happy idea occurred to Dr. Monier Williams, of the Local Government Board, who was conducting the investigation, to photograph its absorption spectrum and compare it with that of the coloring matter of flour, which could easily be obtained in the minute quantity required for this purpose. Inspection of the photographs shows that the spectra are very similar. There cannot, therefore, be any doubt that the coloring matter of flour, if not identical with, is closely allied to, carrotene.

The underlying causes of the relations between chemical structure and absorption spectra have been the subject of much speculation, but it must be confessed that no satisfactory explanation of the phenomena of absorption has yet been formulated, and that the theoretical development of the subject lags behind its practical application.

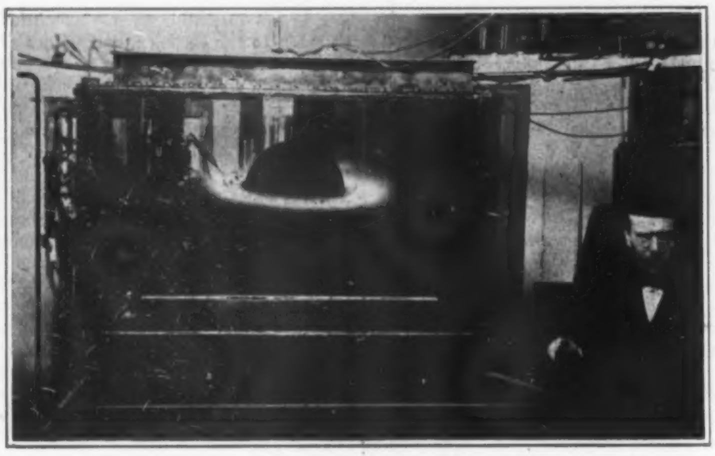


Fig. 1.—Discharge vessel of 1,000 liters capacity, with magnetic cathode globe of 36 centimeters diameter.

Note the resemblance of the discharge to the rings of Saturn. The discharge current is only one or two milliamperes. The floor and ceiling are made of bronze. The thickness of the glass walls is 4.6 centimeters, so that they can withstand atmospheric pressure.

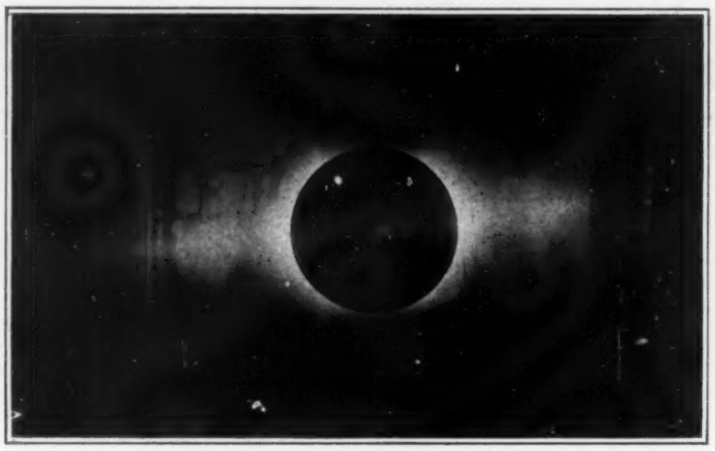


Fig. 2.—Discharge in the same 1,000-liter vessel as shown in Fig. 1, but with high current intensity.

The cathode globe is here only slightly magnetized, but the discharge is now of high intensity, 150 milliamperes. The phenomenon here shown serves to explain the zodiacal light. The view is taken in the plane of the magnetic equator. See also the frontispiece.

The Origin of Worlds

(Continued from first page)

from which disruptive electrical discharges emanate on the sun. I had previously found that these cathode rays, in the presence of magnetic forces, must have an enormous hardness, as indicated in the formula: $H.S=3\times 10^6$ C.G.S, according to which, the intensity of the field multiplied by the radius of curvature of an element of a trajectory normal to the force is equal to three millions at every point. For the purpose of making a comparison which can be easily recalled, it may be observed that the same product, in round numbers, has for different types of rays the following values:

For the cathode rays 300, for the beta rays of radium 3,000, for the canal rays 30,000, for the alpha rays, 300,000, and finally, for my helio-cathodic rays, 3,000,000.

It may be deduced from the foregoing equation that the sun projects its rays under an electric tension of at least six hundred million volts.[4]

The probable depression which many astronomers believe to exist in the photosphere in the region of a spot, can also be easily explained in the light of well-known experiments made with a discharge tube in which mercury is employed as a cathode. A narrow pit is formed in the mercury at the emanation point of the discharge, and the pressure exerted by this discharge on the surface is probably proportional to the energy of the discharge. On the sun this energy must be enormous. In endeavoring to evaluate it, I obtained the huge expression 10^{36} ergs. (loc. cit.).

Returning now to my experiments, Fig. 4 shows a discharge in a fairly large exhausted vessel with a cathode globe, from which long bundles of rays emanate from eruption spots. This phenomenon is more readily obtained if a pair of Leyden jars are placed in parallel with the discharge tube. It will then be observed that electric oscillations are superposed upon the uniformly directed discharges.[5] If now the cathode globe be feebly magnetized, the spots will arrange themselves, as I have stated in the foregoing, in two zones, while the long bundles of rays are curved by the magnetic force, exactly in the way that I assume to explain why a magnetic perturbation reaches the earth as late as fifty hours after the moment when the sun spot, which has caused the perturbation, has passed the central meridian of the sun.[6]

The experiments, just cited, would seem to justify the supposition that the regular oscillations occasionally observed in terrestrial magnetism (elementary waves) are due to slow electric oscillations in the long bundles of rays emanating from sun spots.

If, starting with our experimental analogues, we try to fathom the causes of the eleven-year period of sun spots, we must first know the nature of our disruptive discharges. Here we are constrained to consider a phenomenon which is entirely new in the theory of electrical discharges. These eruptive discharges can be very violent if a very large cathode be used connected in parallel with a large condenser, and if the discharge, moreover, be produced in extremely rarified hydrogen gas, mixed with a little vaseline vapor. With a discharge vessel having a capacity of 320 liters I have obtained astonishing results, using as a cathode the metallic parts of the vessel (the top and bottom of the vessel being made of steel plates) connected to a condenser of one half microfarad. The eruptive discharges emanating from the spots of the steel plates carried with them incandescent particles of steel which were projected vertically on the surface of the cathode.

In order to explain these eruptive discharges it may be reasonably supposed that an insulating jacket of gaseous molecules or ions of a complex character is formed around the cathode globe—an atmosphere which gives rise to a kind of high-tension polarization tending to check the continuous discharges. Perforations, similar, as it were, to short circuits, are produced at certain intervals, in the form of electric eruptions. These eruptions occur at regular intervals, and in the intervals a silent discharge emanates from the surface of the entire globe, as shown in the illustration below. These uniform discharges give rise to a luminous phenomenon which bears a marked resemblance to the solar corona (Figs. 5 and 6). Sometimes it happened, during the experiment, that characteristic luminous bundles emanated abundantly from the polar regions of the cathode globe, exactly like those appearing on the photograph of the solar corona (Fig. 6).

If the magnetic globe is the anode, all the discharge phenomena around the globe are different. Hence it is no longer possible to state that the sun is *positively* charged, relatively to the circumambient space, which several atrophysicists claim to have demonstrated.

With each electric eruption the tension of the discharge increases, while the intensity of the current drops, for example, by thirty and by seventy-five per cent respectively, and the electric corona diminishes. The eruption is then produced with a local deformation of the electric corona near the spot. The silent discharge follows, and the electric corona is then most developed. In this respect it is very interesting to recall that during a sun spot minimum the solar corona seems particularly well developed over a large area around the equator and that the rays are fan-shaped at the poles. During periods of sun spot maximum, the corona is but feebly developed around the equator and the poles, but it has more marked irregular ramifications in other directions.

The great and extraordinary electric capacity exhibited by the cathode globe during the discharges varies slightly with the different conditions under which the discharges are produced. This capacity may be as great as one tenth of a microfarad for a globe twenty-four centimeters in diameter, which, interpreted schematically, is equivalent to stating that there would be found around the globe a double layer of electricity, separated by an intermediate insulating layer of some thousandths of millimeters. If the corresponding capacity for the sun be calculated on the basis of the square of the radius, it would be something like 10^{18} microfarads. It must be presumed that this negative tension, which we have mathematically transferred to the sun, is maintained by radiation, and that the sun, because of its high temperature, sends into space huge quantities of electrons and of positive and negative ions.[7] It may, therefore, be imagined, that, as shown in my experiments, a high-tension polarization is produced on the sun with a negative charge of the sun and that the eruptions, in the form of sun spots, traverse the polarization envelope when the tensions become too great.

The fact that sun spots are relatively stable phenomena, or at any rate that they persist for long periods relatively to my experimental eruptions, is not an essential objection to the hypothesis presented. Indeed, I have succeeded, under certain conditions, in producing on my cathode globes eruptive discharges which lasted several seconds at a time. Moreover, in discharges with liquid cathodes, such as mercury, corresponding stable radiations emanating from the spots on the cathode have been observed.

In experiments with eruptive discharges it almost always happens, when the globe is not magnetic, that luminous ramifications are seen to emerge from these spots, so that the whole assumes the shape of a pointed star (Fig. 7*a*). Sometimes these ramifications cluster together on the diametrically opposite sides of the globe. If the cathode globe is magnetized, some of the ramifications will be seen to turn spirally around the spot near the surface of the globe. On the northern hemisphere of the globe these spirals rotate counter clockwise; on the other hemisphere of the globe they rotate clockwise. Figs. 7*b* and 7*c* show these spirals. The upper part of the globe contains the north magnetic pole. This corresponds exactly with the results obtained by Hale, Ellerman and Fox for hydrogen vortices and calcium vapors around sun spots, assuming that the sun and the earth are oppositely

[4] Phénonènes célestes et Analogies Expérimentales. Comptes Rendus, November 13th, 1911.

[5] Oscillations hertziennes produites par des décharges intermittentes partant des taches isolées d'une cathode dans un tube de Crookes. Comptes Rendus, March 17th, 1913.

[6] Sur la deviabilité magnétique des rayons corpusculaires provenant du Soleil. Comptes Rendus, January 24th, 1910.

[7] Sur la Source de l'électricté des étoiles. Comptes Rendus, November 23rd, 1912.

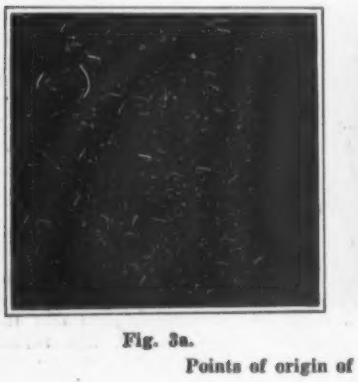


Fig. 3a.

Fig. 3b.

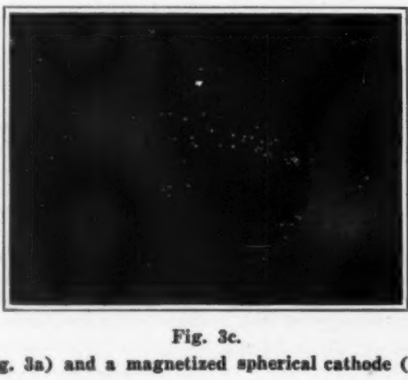


Fig. 3c.

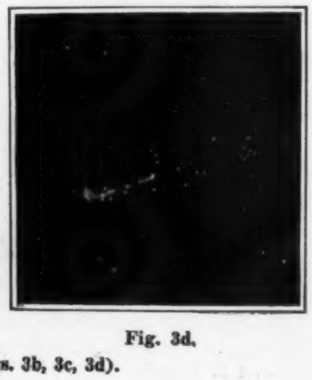


Fig. 3d.

Points of origin of eruptive discharges upon an unmagnetized (Fig. 3a) and a magnetized spherical cathode (Figs. 3b, 3c, 3d).

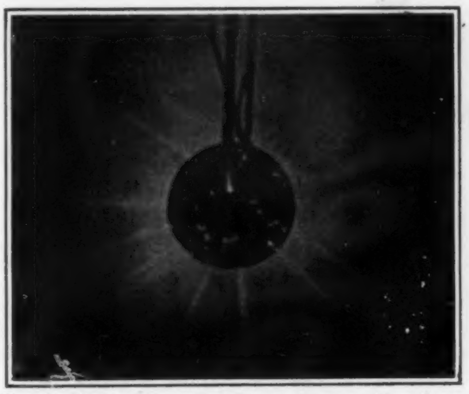


Fig. 4.—Long streamers are seen proceeding from the points of origin of the disruptive discharges.

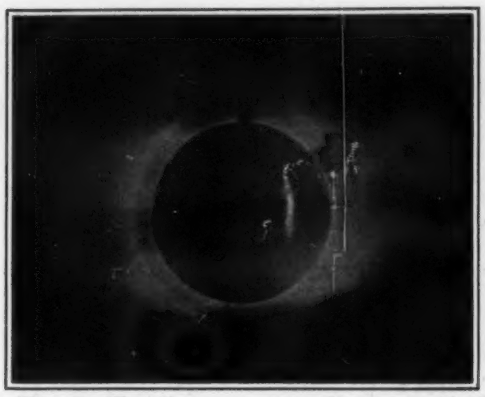


Fig. 5.—Electric corona around a magnetized spherical cathode. Compare also Fig. 2.

Fig. 6.—Excellent photograph of the Solar Corona, obtained at Yerkes Observatory on May 28th, 1900.

magnetized, as I am led to suppose because of the 50 hours' delay in the magnetic perturbations on the earth. I have already called attention to these vortices in my paper of November 13th, 1911.

The last-named illustrations reveal still more. At each discharge a luminosity runs around the equator on the magnetic globe, and the direction of its course is exactly that indicated by the spirals—from left to right. The rapidity of this luminosity's rotation seems to be greater at the equator. The luminous ring is fairly distinct on the photographs. I hope at some future time to take moving pictures of this phenomenon on my thirty-six centimeter cathode globe; the changes are slow enough, especially if a conductor of great capacity, connected in parallel, be employed. As we shall see further on, this investigation is highly important in understanding the different rotations of sun spots in different latitudes.

It seems logical, on the theory which has here been presented, to attempt an explanation of the different daily movements of sun spots by an electro-magnetic action, but up to the present time, this has not been successful. There are still too many unknown features in these electric phenomena.[8]

I will now take up the eleven-year period of sun spots and try to ascertain if, on the basis of my experiments, I may venture to suggest a plausible explanation of the origin of this period.

First of all a cause must be sought to acount for the netic action of the sun. That the sun in its entirety is magnetic, no one doubts at this late day. The various characteristics observed in the corona of the sun, principally in the polar regions, were the first phenomenon that inspired this idea. Hale's discovery of the strong local magnetism which is at times manifested in sun spots has since dispelled any uncertainty on this point. The magnetic moment of the sun, which, according to my calculations, is about 100 times greater than that of the earth, doubtless owes its origin to electric currents circulating in general fairly parallel with the solar equator. But, what is the origin of these currents, and what is it that controls their intensity? Is this intensity itself constant?

It is my opinion that solar magnetism is to be indirectly attributed to these very violent electric eruptive discharges and their long bundles of rays emanating from sun spots. Violent induction currents are generated in the gaseous, rotating core of the sun, a core which, moreover, may be considered as an electric conductor. I have made several attempts to verify my hypothesis mathematically, but I have not yet completed the task. We know that electric currents circulating in large globes, made of good conducting material, have a large persistence.[9] Lamb has found that for a copper globe as large as the earth, ten million years would elapse before the currents would drop to $\frac{1}{e}$ of their original intensity. The inductive effects of electric rays emanating from sun spots and manifested at certain intervals may, therefore, give rise to currents of long duration, if the conditions are favorable. So far as the sun is concerned, it is probable that we shall be compelled to assume a rather feeble conductivity in the gaseous core, so that the electric currents which are there generated and which there circulate are reduced with relative rapidity and transformed into heat.

Adopting this view, I will endeavor to find an explanation of the eleven-year period of sun spots. The results of my original experiments show that the spots corresponding with the electric eruptions on the cathode globe are distributed in two zones, which continually tend to approach the equator as the magnetism of the globe increases. In this connection another remarkable phenomenon must be mentioned. The high-tension polarization, which gives rise to the eruptions, appreciably diminishes when the magnetism increases, while the spots become more numerous per unit of time but also become smaller as they approach the equator.

Something analogous occurs on the sun. It may be imagined that the relatively more powerful eruptions in high latitudes give rise to strong induced currents, which increase the magnetism of the sun—a magnetism which must be presumed to be feeble during a sun spot minimum, since the spots lie in high latitudes. As the magnetism of the sun increases, the number of spots increases, but the heliocentric latitude of the spots diminishes until they reach 16 degrees north and south during the sun spot maximum. If this hypothesis be admitted, it is evident that the magnetism of the sun should increase for a certain time while the intensity of the spots diminishes, and the atmosphere of ions, which gives rise to the high-tension polarization, is more and more deformed by magnetic forces and increases near the equator as the solar magnetism increases. Consequently, the supposition may be permitted that the induced currents in the core of the sun no longer increase after a certain point has been passed, since there are no more active spots, in other words, since there are no more sufficiently powerful eruptions. From this it follows that the currents circulating in the core of the sun soon begin to lose their intensity, since they are transformed into heat; the atmosphere of ions which is the cause of the high-tension polarization then tends to return to its primitive condition, which, for the non-magnetic globe, is unquestionably a jacket of spherical form, concentrically enveloping the globe.

As regards the sun, then, it may be supposed that as the solar magnetism diminishes up to the beginning of the next sun spot minimum, the polarization ions are once more arranged in the order corresponding to what may be called a "period of fatigue."

In Hale's last report[10] it will be found that an attempt has already been made to detect a slight Zeeman effect, due to the general feeble magnetic field of the sun. It is probable that Hale, with the excellent apparatus at his disposal, will succeed in measuring the general magnetism of the sun. I predict that these measurements will lead to the discovery of a strongly marked eleven-year period in solar magnetism. During a sun spot minimum, solar magnetism is also at its minimum. In my opinion the latitudinal movement of the spots demands as the most probable supposition, a similar magnetic period of the sun, or a very marked eleven-year period in the solar electric tension.

If such electric and magnetic phenomena play their part in our sun, as I have just supposed, it is evident that similar occurrences take place in the stars.

In my work "On Sun Spots" (l. c., page 151) I assumed that the eleven-year sun spot period would serve as an example to explain the phenomena of certain periodic stars, such as Mira Cetti and χ Cygni, as well as the sudden appearance of novæ. It may be assumed that in stars on which crusts are about to form, electric eruptions can produce changes more visible than, for example, in our sun, the electric explosives being merged, as it were, in the thermo-dynamic explosives, necessarily present under the newly formed stellar crust after a certain time has elapsed.

PLANETS AND SATELLITES.

We shall now learn how our experimental analogues lead us to the conception that in each solar system, still in evolution, electro-magnetic forces must be present of the same magnitude as the forces of gravitation—magnetic forces which act upon the corpuscles of matter carrying electric charges. It may be imagined that the planets, having orbits almost circular and situated almost in the same plane, could be formed around our sun by the co-operation of all these forces. Around these planets, in turn, satellites and rings are formed, and even in the very depths of space, these same co-acting forces give birth to ring-shaped and spiral nebulæ.[11]

As I have said in the foregoing, the fundamental point of departure in the theory is to be found in the supposition that all the suns, relatively to surrounding space, have an enormous *negative* electric tension, maintained by the radiation of luminous or corpuscular rays. Ex-

(Continued on page 12.)

[8] Sur la Constitution électrique du Soleil. Comptes Rendus, September 4th, 1910.

[9] See Lorberg, Journal de Crelle, vol. 71 (1870) and Lamb, Philosoph. Trans., 1883.

[10] Mount Wilson Solar Observatory, Annual Report of the Director, 1912, p. 179.

[11] Sur l'Origine des planètes et de leur satellites. Comptes Rendus, November 4th, 1912.

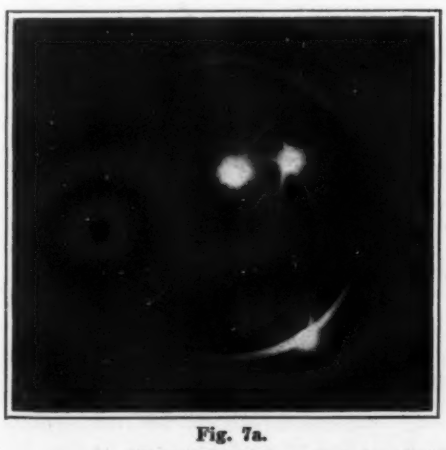


Fig. 7a.

Fig. 7b.

Fig. 7c.

Electric vortices around the discharge spots. They revolve in opposite directions on the two hemispheres separated by the magnetic equator of the spherical cathode.

Pneumatic Tires*

The Most Vital Part of the Automobile

By P. W. Litchfield

The manufacture of pneumatic tires, an industry less than twenty-five years old, has grown until at the present time the value of its product in the United States alone amounts to about $150,000,000 annually.

It has been the practice of automobile and vehicle builders for many years to make as nearly as possible the entire vehicle, but while the pneumatic tire is a component part of every vehicle, no manufacturer of bicycles, motorcycles or automobiles has ever successfully made his own tires, and the number of tire manufacturers has always been relatively very small compared with the volume of the industry.

I do not intend in this paper to go into the story of the process of manufacture of a tire, but to confine it largely to the history of the pneumatic tire design, from the time of its invention in the early nineties to the present time. I wish to point out the causes of the many changes which time has wrought in the design, discuss some of the problems now before us, and correct some of the popular fallacies regarding both the engineering and commercial aspects of the pneumatic tire business.

If we go back to about the year 1890 and look at the means of transportation in vogue, we find that the hauling by self-propelled vehicles on land was confined to the railroads, two smooth parallel rails being carefully laid to form a perfect roadbed to protect the machinery of the locomotive sufficiently to make it a practical commercial proposition. The millions of ordinary roads throughout the country were used for hauling by means of domestic animals only.

At about this time the safety bicycle and rubber tire were developed. This brought to the attention of everyone the simplicity, speed and healthful exercise to be obtained by abandoning the horse and propelling the vehicle by man-power. While the horse could not call attention to the weaknesses of the vehicle which made his work harder and his progress slower, man, when he assumed the duties of the horse, began to analyze. Then began the study and development of the self-propelled vehicle industry of to-day. The development of the internal combustion motor and of the pneumatic tire to protect the delicate machinery from shock followed by various stages. Automobile engineers have been following largely the development of the machine, while the tire man has followed the development of the tire as a means of protecting the machine. While to-day the cost of rubber tire upkeep is one of the largest items of expense in the maintenance of a car, it must not be forgotten that it is the tire which is put where most of the abuse comes, which does for the car what the steel rail does for the locomotive and makes every road possible.

Let us go back to the man on the bicycle. He soon found out that the solid tire was satisfactory on a smooth road, but when it came to a rough road he could feel the bumps and had to slow down, as the impact of the tire against stones and uneven surfaces was more than he could stand with comfort and more than he could propel the bicycle against with his own power for any length of time. Naturally, his next idea was to get more cushion. This resulted in the introduction of the cushion bicycle tire, which was an all-rubber tire with a hole in the center to allow for more distortion in the rubber itself, the cross-section diameter of the tire being increased from $\frac{3}{4}$ inch to about $1\frac{1}{2}$ inches. The rider then found he had gained more cushion, but had increased the weight of his vehicle, so that it required more power to propel the bicycle on *good* roads. It was at this time that the pneumatic tire was invented to increase the cushion, decrease the weight and lessen the power consumption of the tire on ordinary roads. Since about 1893 the only tires which have been used on self-propelled vehicles are either solid rubber or pneumatic rubber tires; no other type seems at the present time likely to engage the serious attention of engineers.

As both of the above-named types are being used in larger quantities every day, let us (before passing to the pneumatic) analyze the difference between them and see under what conditions one seems to be superior to the other. This brings us to the question: In a self-propelled vehicle, what are the functions of the tire? They are, first and foremost, a cushion to protect all parts of the vehicle from the shock caused by the impact against inequalities of the road; second, to provide proper traction, avoiding unnecessary slip. These are the two main functions, and, therefore, the principal thing to be kept in mind in tire design is to satisfactorily accomplish them at as low a cost per vehicle mile as possible, with the least possible consumption of power, and with the least amount of trouble and inconvenience to the driver and occupants. The pneumatic tire depends upon the elasticity or resiliency of a gas, i. e., air, for its cushioning effect, while the solid tire depends upon the resiliency of a practically incompressible solid (i. e., vulcanized rubber). It is needless to say that air is the more perfect cushion and the lighter and cheaper, the cost lying only in the air container. No other *solid* body can compete with India rubber in acting as a cushion by being greatly distorted and recovering its original shape again repeatedly with very little fatigue.

One point regarding rubber must be carefully borne in mind, which is, that vulcanized rubber is practically incompressible; its cushioning effect is only possible by distortion and recovery, and it must be allowed by the designer plenty of room for this action. A glance at hundreds of patents on solid-rubber tires shows that this point has been almost entirely ignored by inventors. Another point frequently overlooked is that the shock may come from almost any direction, owing to varying road surfaces, turning corners, running into curbstones, etc. Many tires and spring wheels carefully designed to take up blows acting directly from the ground vertically toward the rim are utterly unfit to withstand shocks in other directions.

Before selecting between the solid and pneumatic tire, the weight to be carried, the speed to be attained, and the character of the road must be considered. The load to be carried can be worked out satisfactorily on either type. In a solid tire it requires a sufficient amount of properly compounded rubber, and in a pneumatic a sufficient combination of air volume and pressure contained in a suitable retainer. The character of the road and the speed have a great deal to do with the selection of type, as air being a much better cushion than rubber, allows the pneumatic to give much more efficient cushion and traction on rough roads and at higher speeds than is possible for the solid. As far as the efficiency of the vehicle is concerned, the pneumatic would nearly always be chosen as the ideal tire were it not for the fact that in many cases the roads are sufficiently good and the necessary speed sufficiently slow to make the saving in cost per mile on solid tires, due to their longer life, offset the increased efficiency of the pneumatic. Again, the unreliability of the pneumatic due to injury through punctures or blowouts, making attention to it necessary at awkward places and times, often causes the selection of solid tires, as frequently occurs on pleasure electrics for ladies, fire apparatus, mail wagons, etc. In short, good roads and slow speeds are favorable conditions for solid tires; ordinary roads and high speeds for pneumatic tires. The solid tire having less cushion and less motion requires a lower percentage of pure rubber in its composition than the pneumatic, which tends to lower tire mileage cost.

RUBBER SUPPLY.

A lowering of the price of crude rubber will tend to popularize the pneumatic tire, and it is well to bear this point in mind, as the average price of crude rubber will probably be lower each year until it reaches less than one half its present market price. The selling price of crude rubber in the past has been fixed by supply and demand and speculation, with no reference to its cost of production, but its cultivation on a large scale is changing this condition, and it is probable that in five or six years there will be a sufficient amount of rubber to supply the demand at a cost of less than 40 cents per pound, which alone should save $33\frac{1}{3}$ per cent in the cost of pneumatic tires. The danger of the rubber supply running out, which was very serious three years ago, causing rubber to advance to $3 a pound, caused successful cultivation to become an accomplished fact, which apparently solves the question of our future supply. It is hoped that the present scarcity and high price of gasoline will in a similar manner be the means of solving the question of the future motor fuel supply.

THREE TYPES OF PNEUMATICS.

To go back again to the man on the bicycle. His experience with solid and cushion tires resulted in the invention of three types of pneumatic tires at almost the same time, and these three have been the only ones that have been, or are now, used in any quantities. They are the single-tube, invented by Tillinghast; the clincher, invented by Bartlett, and the wired-on, invented by Dunlop. There was great rivalry between the three types for two or three years, resulting in the supremacy of the single-tube in the United States and the clincher and wired-on types in all other parts of the world. The introduction of quick-repair cements, of single-tube repair shops all over the country, and lower cost of production were largely responsible for the success of the single-tube in this country. The wired-on type is still the most popular in other countries.

Following the pneumatic bicycle tire came the pneumatic carriage tire, and each country developed the type of tire found most popular on bicycles. This was a temporary business, however, because the tires were used on horse-drawn vehicles, they did not have to perform the traction or driving functions, and the speed of the horse was so slow that a sufficient amount of cushion could be obtained from solid tires and metal springs without the annoyance of punctures; hence, this type of tire gradually give way to the solid.

Following the pneumatic-tired carriage, about the year 1898, came the automobile with its delicate mechanism and high speed, and with it the demand for a more durable and efficient pneumatic tire. As in the case of the carriage, each country still further developed the type of tire which was most popular and successful on bicycles. American designers went ahead with the single-tube, making it up to 5 inches in size, while England developed the wired-on, and France the clincher. It did not take very long, however, to discover that conditions were quite different on the automobile from what they were on the bicycle, and the French clincher tire made by Michelin and others soon had all the other types "on the run," and English and American tires were at a discount. The wired-on type, which proved so successful on English bicycles, disappeared in the large sizes, because the one-piece Dunlop rim, which was so easy to fit with an inextensible-edge tire in small cross-sections, was almost an impossibility in large sizes. The single-tube American tire when made of a size and thickness necessary for an automobile could be repaired only at great expense and at a well-equipped repair shop. Roadside repairs were impossible. The clincher type soft bead tire was the only practical one of the three for an automobile, and soon became the standard of the world and was made in all countries. The weaknesses of this type of tire which developed were principally the difficulty of forcing the tire (in the large sizes) over the one-piece clincher rim; the necessity for several tire bolts to keep it from creeping on the rim, owing to the stretching of the bead; its depending entirely upon air pressure to hold it on properly; and when overloaded, or much underinflated, rim-cutting, and if run wholly deflated, destruction in a very short time. To overcome these difficulties several mechanically fastened side-flange and bolted-on type tires were introduced, but they required special wheels, special widths and diameters of felloe, were more expensive, and, with the exception of the Fisk bolted-on type, did not make much headway against the standardized clincher tire. The Clincher Automobile Tire Manufacturers' Association had wisely standardized the clincher rim dimensions and insisted on carefully inspecting all rims manufactured, saving to the automobile owners and tire manufacturers hundreds of thousands of dol-

*Reproduced from the *Bulletin* of the Society of Automobile Engineers.

lars, which would have been lost if the unstandardized condition, similar to that which now exists in Europe, had not been remedied.

During five years, from 1900 to 1905, the clincher tire was perfected and standardized. It seemed that it would have no competitor, but the last-named year brought out the invention of two quick detachable rims, the Dunlop and the Goodyear. They were developed to a point that they would fit the same wheels as the clincher rim, and by reversible rings, take either the clincher type of tire or the wire-bead type. These rims overcame, first, the difficulty of stretching the tire over the clincher rim, which was so difficult in large sizes; second, with the removable side ring the tire could be made with an inextensible bead, making it free from creeping by the use of only one bolt on the valve stem, instead of several at intervals around the tire; third, the beads being always against the rim, the inner tube was not as liable to be ruined, in case of puncture, by getting under the beads, and, fourth, a wired-on type could be used with the flanges turned outward, instead of hooked in, making rim injury to the tire less likely in case of overloading and underinflation. The flared-out side ring also made it easier to mount and remove the tire from the rim. This quick detachable type of rim became, a year or two later, the American standard and the wire-bead type of tire began to grow steadily in popularity.

The introduction of this wire-bead straight-side tire met with considerable opposition from the manufacturers of clincher tires, and in meeting it they introduced the quick detachable clincher type. This was a combination of the inextensible wire-bead and the clincher hook. This tire overcame the disadvantage of forcing the tire over the rim, and the pinching of the inner tube when deflated, but possessed no advantage over the straight-bead type, and had the disadvantage of having an extra amount of unnecessary material in the beads; a smaller air volume in the tire; being more difficult to apply and remove from the rim; the addition of the hook bead performing no useful function whatever, except that of a filler to enable its use upon a clincher rim. It would seem inevitable that this type of tire will soon give way to the straight-side type. This narrows down the principal types of pneumatic automobile tires to two forms—the soft-bead clincher tires (to fit the one-piece rims) and the wire-bead straight-side tires (to fit the quick detachable rims). This brings the historical development of the pneumatic tire down to the present time.

VULCANIZATION.

I would now like to discuss some of the differences between the principal pneumatic tires now in the market. Let us first take up the subject of vulcanization. Vulcanization is the chemical change which is caused by the action of heat and time upon the mixture of rubber and its chemical compounding ingredients, transforming it from a plastic dough to a resilient and reacting solid. In order to get a properly vulcanized tire extreme care must be used as to the materials used in compounding, in regard to both quality and amount, and also as to time, temperature and conditions under which the vulcanization takes place. A tire revolving constantly along the road, carrying the weight of the car, and each moment changing its shape and recovering, generates a great deal of heat. This action of heat carried on for a considerable time has a tendency toward affecting the vulcanization. Therefore, all high-grade guaranteed tires are usually compounded so that they take a very long time to vulcanize. This increases the cost of manufacture. Many unguaranteed tires are so compounded that they vulcanize quickly, saving from one half to three quarters of this time, in order to cut down the cost, but the heat generated along the road tends to overvulcanize these tires and they are apt to separate and blow out after a much shorter mileage on this account. The three methods of vulcanizing now in use among the tire manufacturers are popularly known as, first, the one-cure wrapped tread, as examples of which may be mentioned the Fisk, Empire, Ajax and the G. & J.; second, the unit molded type, examples of which are the Republic, Goodrich, Michelin and Diamond; third, the two-cure wrapped tread, examples of which are the Firestone, Morgan & Wright and the Goodyear. Michelin and Diamond tires were formerly made by the third process, but recently have been made by the second. In the one-cure wrapped tread process the tire is completely built over an iron core, wrapped with fabric and put into an open steam boiler and vulcanized in one heat. In the unit molded process the tire is completely built upon an iron core, then put in an iron mold and vulcanized under hydraulic pressure in a press or open steam vulcanizer. In the two-cure wrapped tread process the carcass of the tire is built over an iron core and vulcanized in a mold, the same as in the unit molded type, but not entirely cured. It is then removed from the mold, buffed and cemented and the tread rubber applied and given a second vulcanization. With the Morgan & Wright and Firestone tires this second vulcanization is done while the tire still remains on the core, while in the Goodyear process the tire is inflated by means of an air bag on the rim; in either case after the tire has been cross-wrapped the second cure takes place in an open steam vulcanizer. Each of these three methods of vulcanization has its enthusiastic supporters. Those who use the first two methods claim that they obtain a more perfect vulcanization. They are undoubtedly cheaper in first cost. Those manufacturers using the two-cure process believe that the vulcanization is more uniform throughout the tire and that there is sufficient increase in quality and durability of the tire produced to warrant the extra initial cost.

FABRIC.

Another difference in pneumatic tires is in the style of fabric used, there being two distinct types upon the market, the close-woven fabric tire and the cord tire. Nearly all tires are of the close-woven fabric type as they are more durable, easier to repair in case of injury, and can be operated at a much lower cost per mile. In driving a car considerable power is consumed by the flexing of the pneumatic tires, and it has been found that this loss can be reduced largely by using parallel cords instead of woven fabric, as much as 25 per cent of the power sometimes being saved. The cord construction also permits greater speed and makes an easier riding tire than the square woven type. It is, however, a much more difficult tire to repair and in practice does not work out at as economical a cost per mile as the close-woven type. Its power-saving factor makes it desirable on electric vehicles, where the radius of action is limited by the capacity of the storage battery used. In a fuel economy test with a gasoline car the mileage in many cases could be increased from 15 per cent to 20 per cent by substituting cord tires for the square woven-fabric tires.

SIZE.

The next point to consider is the size of the tire. In the pneumatic tire the load is carried by an air cushion, and the amount of the load carried depends upon the combination of the volume and pressure of air used. For a given weight of car it follows, therefore, that the larger the volume of air in the tires the less inflation pressure required, while the smaller the tire the greater the inflation pressure necessary to carry the load. Tires should be large enough to carry the load with very little flattening of the tire, say not over 14 per cent of the sectional diameter at an inflation pressure which will give sufficient cushion to the vehicle. For instance, a car may be equipped with 32 by 3½-inch tires and be of such a weight that it requires 90 pounds pressure in them to properly carry the load and avoid such excessive flexing of the tire walls as to cause rapid breaking down of the casing. This pressure would make the tire so rigid that the tendency would be to reduce the air pressure in order to get sufficient cushion, which would cause the tire to give short mileage. While, if a 33 by 4-inch tire were used on this car, the air volume would be enough larger to permit the successful use of a lower air pressure, increasing both the cushion and the durability of the casing. The inflation pressure which you see embossed on the casings are the pressures which the tire manufacturers recommend as necessary when carrying the maximum load for which the tire is guaranteed. There is always a certain amount of leaking of the air through either the pores of the rubber or through the valve connections, which causes the inflation pressure in the tire to be greatly reduced. It is frequently the case that a 32 by 3½-inch tire will start out with 70 pounds air pressure and not be reinflated until the pressure is down to less than half this amount. Needless to say, the volume of air being constant, the ability of the tire to properly carry the load is reduced constantly as the pressure decreases. This shows the necessity of frequently testing the pressure with a gage and keeping the tire up to the required pressure. Whatever effort the tire manufacturer makes to put mileage into a tire is of no value unless the air pressure is maintained by the user. The extra power consumed by the use of the larger tire is so small as to be a negligible quantity in present-day cars. It is also to be noted that the larger the cross-section of the casing, the greater the amount of tire wall which comes into action, which reduces the fatigue of the rubber and fabric and lengthens the mileage which the casing will give.

FILLERS.

The use of tire fillers is another question which has commanded the attention of automobilists, owing to the extensive advertising carried on by tire filler companies during the past years. A pneumatic tire casing is designed for use with compressed air; when it receives a blow or shock from an obstruction in the road, the blow is distributed all over the casing, owing to the support of the perfectly fluid air-cushion behind it, the tire absorbing the blow, turning it aside, with very little injury to the casing, except in very severe instances. When a filler is used, the blow is localized in the immediate proximity of the point at which it is received, and the strain falls in one place, thereby weakening the tire. Constant repetition of these blows causes the casing to gradually disintegrate and wear out. The fillers add considerably to the weight of the car, require a great deal more power to drive the car, and do not absorb the shocks to nearly the same extent as in the case of air. Air retains its resiliency and is as perfect after being in use a year as when put originally into the tire, whereas the original maximum resiliency of a tire filler decreases gradually. The detrimental effect of the fillers was shown by the withdrawal of the tire guarantees as well as car guarantees by nearly all the principal manufacturers when tire fillers are used. Another disadvantage of the filler is that as the casing stretches, the filler, being a solid body, does not follow up the casing with a constant pressure, whereas air, being a gas, maintains its pressure continually, regardless of the flexing and stretching of the casing. The casing cannot carry the load for any considerable period without the required pressure in the case of a tire filler any more than it can with air. Substitutes for air other than solids have been used, especially different forms of gas. The use of these various gases as proper means of inflation has been questioned by the tire manufacturers, not because they are chemically injurious to the rubber, but because they filter through the walls of the inner tube much more rapidly than air, consequently reducing the inflation pressure. Carbonic acid gas at usual riding temperature will leak through the walls of the inner tube many times faster than air. It has even been demonstrated that with air, the oxygen seeps out much faster than the nitrogen. The disadvantage of the carbonic-acid-gas-inflated tire is that the user does not realize how fast the pressure is reduced and does not restore it quickly enough. When sufficient care is used, and the inflation pressure is frequently tested, there is no reason why carbonic acid gas should not be as desirable as air.

RIMS.

Before closing I would like to touch upon the subject of rims for pneumatic tires, as it is of the greatest importance to the tire that it be fixed upon a properly designed rim. With clincher tires especially the exact contour of the hooks is of great importance, as it takes only a very little variation from the standard to completely ruin the tire. The proper design for the width between clinches on a clincher tire has been standardized at 60 per cent of the nominal cross-section of the tire. It is the writer's opinion that the proper dimension for the width at the heel of the bead for the straight-side wired-on tire is 66⅔ per cent of the nominal cross-section of the tire, flaring outward from the heel of the bead. The less the required flexing of the casing when the tire is overloaded or insufficiently inflated, and the larger the supporting surface given by the rim to the tire where the flexing occurs, the less the tendency toward rim-cutting. The ideal rim would give continuous support to the tire, especially where the tire leaves the rim on the sides. Split and open side rings should be avoided as far as possible. When split rims are used, it is also absolutely necessary that they be in perfect alignment.

The Origin of Worlds

(Continued from page 9)

periments have shown us that, whenever electric discharges occur in a vacuum, such as those under consideration in my experiments, the negative pole projects particles of matter with a velocity which may become relatively high, if the electric tension employed is great and the temperature high.

If, for example, the negative pole (the cathode) is a small platinum plate about two millimeters square, objects having an area of several square centimeters can be completely covered in two hours with the most brilliant platinum mirror when placed at a considerable distance from the cathode.

The conditions under which the experiments are made determine whether the particles thus projected from the cathode become colloidal corpuscles, accumulations of molecules, or even separate atoms. The problem of what happens to these electric corpuscles, which are projected from a central body, for example, the sun, can be mathematically solved.

It seems that a large portion of the corpuscles can be hurled completely out of the system, never to return to it, that another considerable portion will fall back on the central body, as the result of gravitation, while, finally, a third and smaller group of corpuscles will cluster together and form planets revolving continually around the sun. This last group of particles has been especially studied in extensive researches. The particles of which the group is composed are projected only in the equatorial magnetic plane, and experiments have shown that the electric discharges take place *preferably* around this plane.

The front page illustration pictures an interesting experiment in which a small cathode globe, 2.5 centimeters in diameter, emits rays in the magnetic equatorial plane. The plane of the rays is intercepted by the glass walls of the large discharge vessel (320 liters) in the form of a well-defined phosphorescent band. In my new large receptacle (1,000 liters), in connection with which I shall employ a cathode-globe still smaller (its diameter will be a little less than a centimeter), I hope to produce a phenomenon conforming with and analogous to that produced by the sun when it emits a plane of rays having the diameter of the earth's orbit, which I shall require in order to explain the origin of the zodiacal light.

In the experiment referred to above, and illustrated on the front page, the magnetism of the cathode globe has been so selected that almost all the cathode rays are found near the equatorial plane. Considering the case in which the particles of electric matter would be projected beyond the sun, the movements in the plane of the rays will correspond as a whole with the movements imparted to the third group of corpuscles mentioned in the foregoing. The other particles projected from the sun would be precipitated to infinity, or would fall back on the sun. It can be demonstrated that they cannot cluster together in a considerable aggregation.

Mathematical analysis leads us to the conclusion that, for particles of this character in the equatorial plane, a whole series of limiting circles exists which certain groups of corpuscles approach asymptotically. It can be demonstrated that the condition necessary to enable a particle to approach a limiting circle having a radius of nr_0, when $n>1+\sqrt{2}$, is that the following equations should hold for values of ϑ between the limits $+1$ and -1.

$$\text{(1)} \qquad \frac{r_0 v_0^2}{-\mu} = 2 - \frac{1}{n} + \frac{1}{n(n+\vartheta\sqrt{2n+1})}$$

$$\text{(2)} \qquad \frac{v_0^2 r_0^4}{\lambda^2 M^2} = \frac{\left[2 - \frac{1}{n} + \frac{1}{n(n+\vartheta\sqrt{2n+1})}\right] (n+\vartheta\sqrt{2n+1})\,(n+1+\vartheta\sqrt{2n+1})}{n^3}$$

$$\text{(3)} \qquad l-2 = n+\vartheta\sqrt{2n+1},$$

where

$$l = -kn, \qquad n = \frac{r}{r_0}, \qquad r_0^2 v_0 \sin\alpha_0 = \lambda M(1+k),$$

in which r_0 is the radius of the central body, v_0 the initial velocity of the particle in the direction α_0, and in which λ, μ and M are certain constants.

Our equations lead us to the result that the corpuscles in question assemble around certain definitely located circles in the equatorial plane. Those having a relatively larger mass with respect to the electric charge will arrange themselves in circles at a small distance from the central body, while those which have a relatively small density continue their course in paths more remote from the central body.

When the particles have lost their electric charge, which happens soon after their projection, they begin to describe ellipses of slight eccentricity, with the central body as a focus, provided that the distance which separates them from the central body is great relatively to the radius of the latter.

Finally, under conditions otherwise similar, the *positively* charged particles will form planets revolving directly around the sun in orbits having a radius less than that of *negatively* charged particles, which will gather around the sun in a retrograde movement in orbits of long radius. To meet that condition, it is supposed that the sun is magnetized oppositely to the earth, which, as I have shown previously, is a necessary hypothesis.

All these results can be applied to our solar system, which we must consider as having been originally a large central body, which, in the course of time, has projected electric particles into the circumambient space.

The recent astonishing discovery that the outer satellites of Jupiter and Saturn revolve around their parent bodies in a direction opposite to that of the interior satellites—a discovery which has placed older theories in a difficult position—agrees with my theory. Indeed, my theory enables me to prophesy that if new planets are ever discovered beyond Neptune, it will probably be found that they revolve around the sun in a direction opposite to that of the interior planet. It may be assumed that the 700 planetoids and more, whose orbits lie beween those of Mars and Jupiter, were originally formed by a ring of dust, which in any case has not yet been able to consolidate into one or several large planets.

The rings of Saturn may be considered, in part at least, as dust rings in a slightly advanced stage. Ten satellites have already been formed; all ten are situated nearby in the plane of the rings, and the outermost has a retrograde movement around Saturn. But it may be inferred that several satellites may still be formed by the ring before it disappears and that their number will be reduced in the course of time by collisions.

In order to maintain these hypotheses, it must be experimentally proved that the metallic particles, which, as a result of electric disintegration, are projected beyond a *negative* metallic pole in a Crookes tube, carry a *positive* charge with them for the most part.

In accordance with the sun's actual magnetization the planets should revolve, according to this theory in a direction opposite to that which they in reality pursue, if a negative pole (the sun, in the present case) projected only negative particles, which, *a priori*, would seem reasonable. In order to throw light on this point, which at first blush would seem fatal to the theory, I have conducted a long series of experiments which are not yet entirely completed. But the results obtained up to the present time are nevertheless most encouraging. I have succeeded in producing long bundles of rigid positive rays, undoubtedly formed of atoms bearing a positive charge, and the length of the bundle of rays appreciably increased with the electric tension employed and with the temperature of the cathode. I have obtained rays from palladium, platinum and uranium, with 15,000 to 20,000 volts at the cathode (the positive pole being grounded) and with temperatures of about 1,200 to 1,800 deg. Cent. Under certain conditions I have succeeded in producing bundles of rays from platinum, for example, which, after sufficiently long discharges, produced well-defined shadow-images in the form of metallic precipitations on a glass plate.

From these experiments it would seem to follow that these positive rays of metallic atoms have some of the most characteristic properties of alpha rays. The manner in which they are formed in the solid matter of the cathode and the manner in which they are extended and checked in the surrounding medium speaks in favor of this idea.

I have also succeeded in penetrating with platinum rays, and above all, with metallic uranium rays, thin aluminium sheets, just as it is possible to do with alpha rays.

I will now describe more in detail two of these experiments:

The rays emanating from a small palladium cathode were projected through a small hole in a metal capsule completely closed and connected with the earth, then passed between two slightly separated parallel copper plates. One of these plates was impressed with —200 volts, while the voltage of the other, which was connected with the earth, was zero. After three hours the layers of palladium were quite different on the two plates. On the —200 volt plate there appeared a long and thin bundle of rays, fairly well defined, in which the precipitations were very abundant. But over the *entire* plate (which was 10 centimeters long, and 5 centimeters wide) and even on the back there was a thin layer of palladium. On the other plate (zero volts) which was of the same size, there was a short and thick fan-shaped deposit quite different in character from that on the —200-volt plate; besides, no supplementary layer was to be found anywhere on the plate, either in front or in back. This experiment was repeated more than twenty times in various ways, with always essentially the same result.

I explain the thin and diffuse layer on the —200-volt plate in the following way: After the metallic rays have lost their velocity, they are electrostatically drawn uniformly toward the —200-volt plate, and all around it.

In the experiments which were made to demonstrate that the metallic rays penetrate a sheet of aluminium, I proceeded in the following manner:

In the cover of a small copper box, I drilled, very close to one another, four small holes having a diameter of 0.5 millimeter. Then I took a leaf of the thinnest aluminium (about a thousandth of a millimeter) and, with the aid of the microscope, I selected some small whole parts which were placed in one, two, three and four layers over the small holes. A glass plate was placed beneath the hole. A small steel magnet was mounted behind the box to deviate the ordinary cathode rays, the cathode being placed at a distance of 20 millimeters in front of the holes in the box. After the discharges had continued for one to two hours, the box was opened and the glass plate examined. The metallic precipitations, which had passed through the aluminium leaf, were not so marked that they could be distinguished with the naked eye, but when the plate was breathed upon, a well-defined round spot appeared under the hole which had been covered with one layer of aluminium leaf. Under the hole which was covered with two layers, a spot could also be clearly seen; under the hole covered with three layers, the spot produced by the breath could be distinguished only with difficulty; but under the fourth hole, which was covered with four layers of aluminium, it was impossible to distinguish even a trace.

Some of the cathode rays, hard as they were in these discharges, had very easily penetrated four layers of thin aluminium leaf, and those rays in the majority of cases having, moreover, been diverted by a steel magnet, it may rightfully be supposed that, not the cathode rays, but the metallic rays, modified the glass plate in passing through the aluminium leaves. These experiments will also be continued, as well as those for determining the charge and the mass of the metallic corpuscles.

One point should again be emphasized in these experiments. In the foregoing I have stated that, under certain conditions, strong oscillations could be set up in a circuit coupled in parallel with the anode and cathode as poles (*l. c.* March 17th, 1913). From these experiments it follows that the disintegration of the cathode, under the conditions stated, is much more marked, and that in this case, the bundles of luminous rays emanate from different points of the cathodes. Moreover, at these points the cathodic material is very much disintegrated, so that, under the microscope, the surface of the cathode appears to have been corroded, and to be finely pitted. These experiments have also rendered it possible to prove that in order to obtain an abundant discharge of positive metallic rays from the cathode, it is not necessary to maintain a temperature as high as that indicated in the foregoing, when the cathode is connected with an oscillatory circuit.

It is known that the rays which are known as alpha rays, are composed of positive atoms of helium projected at high velocity from radio-active matter, as for example, from radium. It would seem to follow from the discoveries mentioned in the foregoing that the motion of alpha rays can be extended and made to embrace equally the rays emanating from all positive atoms and projected with such velocity that they exhibit the same properties as alpha rays. The processes which serve to produce these rays may be designated by the name "electro-radioactivity."

In spite of the experiments which are being constantly made, it has not yet been possible to obtain proof that it is possible by electro-radioactivity, to transmute one chemical element into another, and it has not yet been possible to prove whether the disintegration of a cathode develops heat, as when radium is in process of transformation. This last point would be of capital importance in determining the question of the source and duration of the heat of the sun and the stars.

If a transmutation of elements, as Ramsay claims to have demonstrated, can be produced by the action of the radio-activity here presumed to exist, we are justified in supposing that the gases of which our atmosphere and the oceans were originally composed, were produced by a degradation of elements in the course of the same electric disintegration of terrestrial matter which finally led to the creation of our moon.

The well-known researches of Ritter lead us to suppose that if the temperature of the solid surface of a celestial body passes a certain critical point, the atmosphere of this body will have no limit, and the gases will escape into space. The atmosphere of the earth seems therefore to have been formed at a relatively late period. It is also likely that the atmosphere and the water of the earth will disappear little by little, the extreme layers of the terrestrial envelope, which also contain cosmic dust, being subjected to the action of the solar rays to such a degree, that, in spite of gravitation, a certain number of gaseous molecules—especially those which are heated by the dust—will steadily be lost in outer space.

(To be continued.)

The Human Machine—How It Works

The Living Body Not Exempt from the Rule of Physical Law

It is a commonplace of knowledge to-day that the body is a machine demanding food for fuel and transforming the stored energy of that fuel into various forms of energy, such as heat, muscular power, the secretory action of the glands, and nervous and cerebral activity. It is also well known that the law of the "Transformation of Energy Without Loss" is strictly observed, but it is less than forty years ago that this was brilliantly and precisely demonstrated by the famous Prof. Rübner—lately an honored delegate to the Hygienic Congress in Washington—when he proved that the amount of heat produced and given off by any organism within a stated period exactly tallied with the amount of heat calculated from the chemical reactions taking place in the same time.

The analogy with a machine is obviously imperfect, however, since the animal organism demands food not merely as fuel but as a building material. Unless sufficient food is taken to repair waste of tissue as well as to furnish heat and power, the body must gradually waste away, until death ensues from slow starvation—a process which may be very prolonged, as in the famous case of the horse trained to eat one straw less per day. In fact, some instances have been observed in which there was nearly 50 per cent of loss of weight before death occurred. Absolute starvation, of course, brings dissolution much more quickly, the time varying according to the size of the animal, its previous condition of nourishment and the surrounding temperature. Death came to a nine-year-old horse after twenty-four days of starvation, to a large dog after sixty days, and to a guinea pig after six days.

Moreover, though the transformation of energy in the animal body is quantitatively the same as in a machine, it is not qualitatively the same, since the processes of slow combustion in the body by which the complex molecule is broken up into simpler forms are far more complicated and subtle than the rapid combustion which liberates the heat and energy of fuel in an engine.

These processes of combustion, involving the intermediate stages of assimilation, were instructively discussed in an address given by Prof. Luthje in the auditorium of Kiel University on the Emperor's birthday, and are here reproduced from the *Deutsche Rundschau:*

"The standard of heat measurement in the body," we read, "is the calorie, as in physics. When one gramme of albumen is burned in the body 4.1 calories are produced and the same is true for carbohydrates, as sugar, while 1 gramme of fat gives 9.1 calories. This does not correspond with the actual value of the combustion of these substances in the calorimeter, but is the available value in the animal body, in which the combustion is not always complete, e. g., albumen is transformed only so far as urea is concerned.

"The conservation of matter in the body is as absolute a law as the conservation of energy. The elements, albumen, fat, and carbohydrates, re-appear with quantitative exactness, except when retained as material for growth, reconstruction, or deposit. . . . Hence the greater the work done by the organism, the greater its need for food. The peculiar sensation of the appetite, therefore, is merely an expression of the need of the cells at that moment for more energy. But the appetite is not always reliable, being sometimes less than the actual needs of the body, as in certain illnesses, and sometimes greater than those needs when stimulated by the pleasures of the palate. In the former case there is a loss of weight, in the latter, an increase, owing to deposits of excess matter, usually in the form of fat. That surrounding temperature affects the food needs is obvious, but certain factors entering into the specific liberation of heat by different individuals are not so well known. Man has acquired in a very high degree the capability of maintaining his bodily temperature independent of the surrounding temperature, by means of a series of devices of a physical nature such as the variable size of the vessels of the skin, the variable amount of perspiration, etc."

But there is another factor of the first importance which cannot be altered by the animal either by reflex action or will-power: this is the area of the superficial surface. The greater the surface the greater the loss of heat and the greater the food need. The difference may be absolute, as that between the infant and the adult, or comparative. According to a law of mathematical physics, the smaller organism has in comparison to its weight a much greater surface than a larger body has in comparison to its weight. Hence it is clear that reckoning by the kilogramme of corporeal substance, the small animal or the child has a much greater transformation of energy than the larger animal or the adult.

Among the intermediate processes of combustion in the body the "ferment functions" are of the highest importance. By the term ferment is denoted a body which by its mere pressure induces or accelerates a chemical reaction in which it does not itself take part, as in the change of grape sugar into alcohol and carbon dioxide. In this case the ferment is furnished by the hop and the process is analytic. Other ferments are synthetic, building complex from simple compounds; still others facilitate the carrying over of oxygen. Such a fermentative process occurs when the ptyalin of the saliva breaks up starch into simple sugar molecules. In the stomach the albumens, and to a less extent the fats, begin to be split up, and in the intestine all three are acted upon by suitable ferments excreted partly by the wall of the intestine, but chiefly by the pancreas. Continuing, the author states:

"The splitting up of the large molecules is partly to secure solubility and partly springs from the fact that the nutritive elements of the food are chemically different from the same elements as are required by the body. Plant starch behaves in a chemically different manner from its animal equivalent glycogen. The albuminous bodies of plants and animals are at least in part different from those of human tissues.

"The albumen in the food is split by the ferments into a series of single products known from their chemical composition as animo-acids, which are in general found in every albumen molecule, whatever its origin, but which are present in the different albuminous bodies in varying quantities and in different spacial arrangement. This explains the large number of such bodies, of which about fifty are already known and many more apparently exist. Through this fermentative splitting up of the food ingested, the organism is enabled to rebuild the required albumen of its own body by means of a quantitative and qualitative selection from the mixture of amino-acids in the intestine.

"To what extent the organism makes use of this capacity is evident from the fact that even in the blood vessels just beyond the wall of the intestine there no longer exists any trace of foreign albumens or their decomposition products. At first, indeed, only the blood albumens are found. This uncommonly complicated act of albumen synthesis, long vainly attempted in the laboratory, is therefore accomplished by the cells of the intestinal wall, apparently by the action of the ferments."

Following the process further, the albumen of the body is continually either undergoing combustion or being used as building material, as in growth. In the former case there is apparently another splitting of the molecule by ferment action, and to the division products resulting from this, still another group of ferment, the oxydases, bring oxygen, through which the final combustion is achieved. And according to our present knowledge we can explain these intra-organic, or perhaps directly intercellular changes, only by saying that there is here, too, another breaking up into single smaller nucleal compounds followed by a definite reconstruction of the specific cell albumen. How this is done is not known at present, but by analogy we must assume fermentative processes again.

"Some comprehension of the extent of these transformation processes can be gained from the consideration that in the case of the suckling child the whole series of different albumens of the muscles, blood, nerves, skin, bones, connective tissues, etc., must be made from the remarkably scant albumens of the mother's milk, therefore chiefly from casein and lactalbumin; . . . the more remarkable since the characteristic albumen of milk must in its turn be constructed from the different cell-albumens of the mother's organism.

"That similar processes are concerned in the case of the other elements of nutrition let one more example suffice—that of the building of the specific sugar of milk from the grape sugar of the blood."

Prof. Lüthje states further that certain diseases of faulty metabolism, such as diabetes, gout, and many cases of obesity are now looked on as due to disturbance or exhaustion of the ferments. This explains why diseases so different in nature all seem to be heritable, or at least frequently recurrent in the same family even to a degree indicating race degeneracy. "The common factor in all is merely the exhaustion common to all, of certain fermentative functions."

The ferments appear to be always ready for action when needed. Hence a question arises as to the origin of the stimulus which rouses them when required. The intermediary between such stimulus and its effect resides in the reflex apparatus of the body. The reflexes are divided into the chemo-reflexes and the psycho-reflexes. An instance of the former is the secretion of tears following a pinch of snuff taken by a person unaccustomed to it. A good example of the latter is the involuntary protective movement which follows the sudden placing of a fist under a man's nose. The optic nerve transmits the sensation to the brain, this by intellectual, psychic activity forms the idea of the blow, and this gives rise to the reflex protective movement.

"A long series of the daily actions of the body are due to such reflexes, and in no part of the body do we know their wonderful operation better than in the early processes of digestion. . . . How delicately such reflexes are adjusted is best shown by some of the results of the experiments of Pawlow, the greatest investigator of this field in the last ten years."

If ice water, snow or small pebbles be thrown into a dog's mouth, no drop of saliva flows, whereas a copious flow follows a handful of sand. "The reason for this is obvious. The first three are easily ejected, but to get rid of the sand requires a liquid. If dry edible substances be given the saliva flows freely, but more sparingly if they be moist. We have here, therefore, a reflex action of the first digestive glands exactly adapted to the physical nature of the food." More marvelous still, when the dog has been trained by repeated trials to know the food or recognize its containers, the proper flow of saliva follows the mere sight, a true example of psycho reflexes. "Pawlow is undoubtedly right when he speaks of the psychology of the salivary glands." Another striking instance may be cited. Dogs have the habit of licking their wounds. If purposely burned at any point of the body a flow of saliva follows, the only exception being the top of the head, the only part the dog is unable to reach with his tongue.

Similar reflexes, partly psychic, partly chemical, are concerned in the digestive action of the stomach, intestine, and pancreas. The different kinds of food or their varying mixtures occasion a suitable flow of the different digestive juices, and such flow may be caused psychically by the mere sight, taste, or odors of such substances. Thus, when a piece of bread smeared with sausage is held in front of a dog thus trained, the effect on eye and nose produces an immediate flow of the fluids proper to digest bread and sausage.

The Falling of Leaves and Rain

A meteorologist of Auxerre, M. David, had wondered if there exists a relation between the precocity of the falling of the leaves from the trees and raininess. His observations have especially dealt with the lime trees on avenues, which can only draw their nourishment at a certain depth. From the observation of a dozen years he concludes that the meteorological circumstances of the summer are not always sufficient to explain the fall of leaves.

When the winter has been sufficiently damp to assure reserves in the deep layers of the soil, it seems that the foliage has nothing to fear from heat and drought. It suffers more from the cold. Premature frosts accelerate very decidedly the fall of the leaves.

The different vegetable species are also very differently influenced. Thus in 1907, in spite of the provision of water in the sub-soil, the lime trees lost their leaves two months before the plane trees and the fruit trees. The relations between the climatic conditions and the fall of the leaves of trees are very complex.—*Chemical News.*

The Large Cetacea are Disappearing

Like the elephant of the Black Continent, which will be totally exterminated by ivory hunters in seven or eight years' time, the whole of the other large cetacea living in the sea off the east coast of Africa will, if care is not taken, certainly disappear in a still shorter time, and that to the great detriment of the public fortune. Such is the cry of alarm uttered by M. Perrier, Director of the Paris Natural History Museum.

Several years ago M. Gruvel, during his explorations on the African coast, had remarked the prodigious abundance of large cetacea: Narwhals, dolphins, porpoises, and spermaceti whales. He had called the attention of the Government and of French industry to these enormous riches, but the matter was not taken up, and no attention was given to his reports on this interesting question. And to-day more than thirty companies are engaged in the fishing of the large African cetacea.

To give an idea of the enormous quantity of marine animals thus destroyed, it is to be remarked that all these companies are making profits varying from 20 to 400 per cent. Now for the crew of a whaler only to cover their expenses they must capture from 100 to 150 cetacea.

M. Perrier declares that unless, in a brief delay, an international convention interferes to put a break upon these hectacombs there will not be a single cetacean left on the African coast in two or three years' time.—*Chemical News.*

The Undulator*

A Modified Reciprocator for Ornamental Lathes

By A. S. Rogers

"Atkinson's Reciprocator," as an adjunct to the spiral apparatus of the ornamental lathe, is well known to ornamental turners. By this appliance simple waved lines are produced lengthwise upon cylindrical and taper forms, and radially upon surfaces, by combining

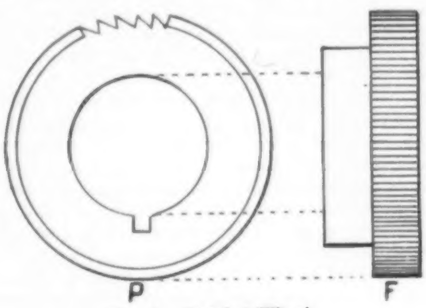


Fig. 1.—Ratchet Wheel.

a rocking motion imparted to the mandrel by an eccentric clamped to one of the gear-wheels with the traverse of the tool or a revolving drill in the slide-rest.

The chief difference between the original apparatus and that now to be described lies in the substitution

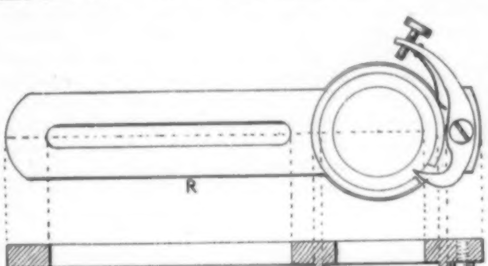


Fig. 2.—Radial Lever.

of "cams" for the eccentric. Cams may be either counteracting or single-acting. The counteracting cam, as its name implies, gives a positive motion; while the single-acting requires the use of a spring or weight to obtain the return action. The cam has this great advantage over the eccentric, that as its shape can be

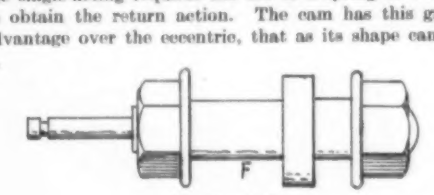


Fig. 3.—Axle

varied to an almost unlimited extent, so the motion imparted by it will be similarly varied. With cams, undulations can be produced on the work such as zigzag or dog-tooth patterns, step patterns, and complex patterns composed of curves, angles, and straight lines. By the adoption of the single-acting cam, patterns may be made to proceed spirally round cylindrical and taper work. Spiral effects were obtained by the older apparatus; but what is referred to here is the spiral advance round the cylinder of the single waved or undulated line. Another variation can be produced which is analogous to the effect of the stop-screw upon the Rose cutting-frame, which limits the action of the rosette by preventing the roller from descending to its full depth.

* Reproduced from the *English Mechanic*.

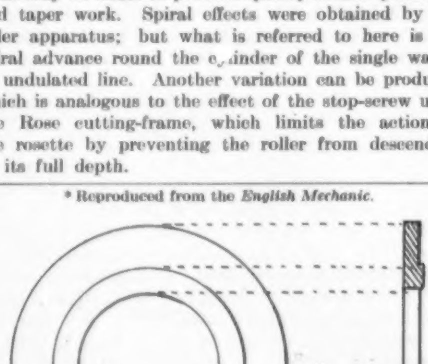


Fig. 4.—Washer.

Enough has been said to show that a considerable addition may be made to the powers of the original appliance; but before commencing to give details of construction, it will be well to premise that correct measurements can scarcely be given to suit all lathes. The parts to be described may be adapted to any lathe which has facility for fixing a gear-wheel at the rear end of, and outside, the headstock. It is presumed that there will be a feather or studs let into the mandrel at this point, upon which the screw-guides of the traversing mandrel or the pinion-wheel fit.

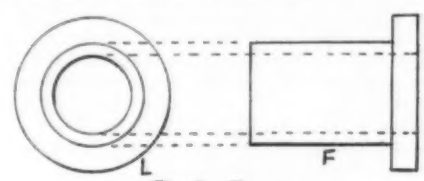


Fig. 5.—Sleeve

A gunmetal wheel is bored out to fit upon the mandrel and turned up to 1 11/16 inches diameter and ⅝ inch in thickness, and the keyway is cut. One side of the wheel is then reduced to form a boss 1¼ inches diameter and 5/16 inch long. This leaves the edge of the wheel 5/16 inch thick. This edge is cut into ratchet-teeth, forty-eight in number, and the direction of the teeth the same as in Fig. 1. This wheel and the boss of the radial lever, which is hollowed out to receive it, together form the dividing-chuck. The radial-lever has a long slot instead of the numbered holes of the older apparatus (see Fig. 2). Its dimensions are 6¾ inches long over all, by 5/16 inch thick, by 1¼ inches wide; boss 1 15/16 inches outside diameter, thickness of boss and lever together ⅝ inch. The slot is ⅜ inch wide. The ratchet-wheel is wholly contained within the thickness of the lever and boss, and should fit freely, but without shake. The axle which rides in the slot is shown in Fig. 3. It is ⅜ inch diameter, and 3/16 inch thick. Both ends are tapped and fitted with 5/16 inch nuts, and the end of the axle is drilled up and carries a steel pin, upon which is hung the spiral spring which provides the return motion required by the single-acting cam mentioned above.

A short continuation of the radial lever carries the long-tailed ratchet shown in Fig. 2. The milled-headed

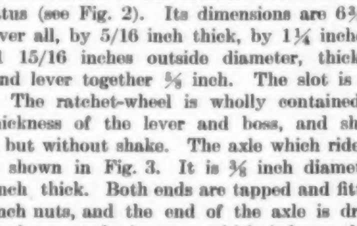


Fig. 6.—Cam-Wheel Axle

screw, which is tapped through the tail of the ratchet, locks the ratchet-wheel and radial lever together after using the device as a dividing chuck. When a movement of the ratchet-wheel is required the screw is slackened, and the click of the ratchet is easily counted as the lathe pulley is slowly moved round. The wall of the recess in the boss is cut away at one point to allow the point of the ratchet to reach the teeth.

The ratchet-wheel is placed upon the mandrel first, with the boss outside; the radial lever is next put on over the wheel, the large washer with the raised projection, as shown in Fig. 4, is put in place, and then all are screwed up with the nut or screw at the end of the mandrel. The projection on the washer bears upon the boss of the ratchet-wheel, so as to fix it, while still leaving the lever free to move when the milled-headed screw is loosed.

In the original apparatus the hub of the eccentric and a gear-wheel were clamped together upon a revolving axle. In the present case the cam is screwed to the boss of a gear-wheel with two 3/16 inch countersunk head screws, and the axle on which they work is a fixed, and not a revolving, one. A special wheel should be made, of 120 teeth; the boss should be 1½ inches across the face, not larger; the bore is to be ⅝ inch, and the thickness the same as the other wheels

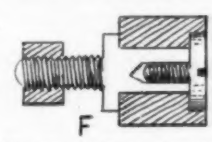


Fig. 8.—Roller and axle.

of the set. With this sized wheel and a suitable combination of the gear-wheels, the wave length may be reduced to 2/10 and increased to 3 inches or more. To fit the ⅝-inch hole in this wheel a steel sleeve will now have to be made, ¼ inch longer than the thickness of the wheel, and with a thin collar at one end

Fig. 9.—Stop-plate.

3/16 inch thick and 15/16 inch diameter (see Fig. 5). The hole through the sleeve is to be ½ inch, as this is the size of the axle on which it will run. In use the sleeve centralizes the cam upon the wheel, and allows both to be screwed together without tightening the running fit upon the axle. It also prevents the wearing of the holes in the wheel and cam.

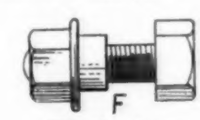


Fig. 10.—Stud.

Fig. 6 shows the cam-wheel axle, the sizes being collar ¼ inch thick and 1½ inches diameter; fitting for banjo plate 1 inch diameter filed down to ¾ inch to fit slot; thread 1/19 inch pitch = ⅜ inch gas-barrel thread, length ⅝ inch. The axle is turned up ½ inch diameter to fit the sleeve, the end is reduced and tapped 5/16 inch, and a hole is drilled up the end for a steel pin to carry the lower end of the spiral reaction spring.

The next part to be taken in hand is the connecting-arm, which is shown in Fig. 7. This is a flat arm 9¼ inches long, 1½ inches in width at the wider end, and 1 inch at the narrower. The total length of the arm

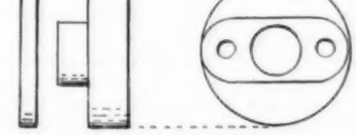


Fig. 11.—Sliding boss.

may be shortened if the size of the banjo-plate requires it. The slot is 3 inches long by ⅝ inch wide, and the boss is ⅞ inch diameter by ⅝ inch through the hole, which is bored out ⅜ inch to fit upon the axle (Fig. 3). At distance ¾ inch from the inner end of the slot a ¼-inch tapping hole is drilled and tapped. This is to carry the axle for the roller which is operated upon by the cam. Fig. 8 shows section of roller, and its axle, locknut, and retaining screw. The roller is ¾ inch

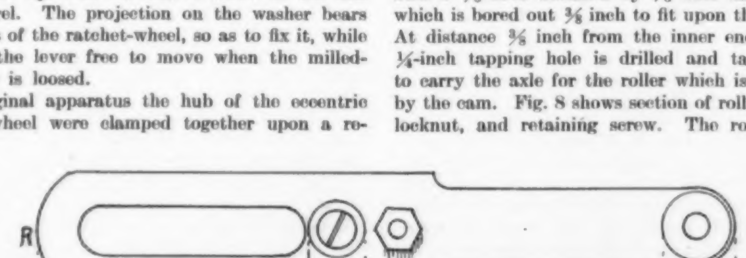


Fig. 7.—Connecting Arm.

diameter and ½ inch long, 5/16 inch in the hole, recessed at one end for the head of the retaining-screw, and is casehardened. The locknut serves a double purpose. It is only ⅜ inch diameter, and being made cylindrical, it has a saw-cut across the end, to allow of it being screwed up with a forked screwdriver. The

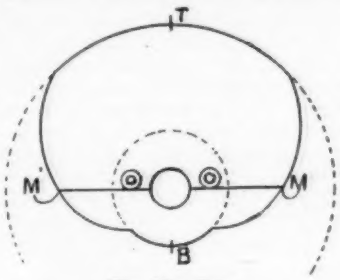


Fig. 12.—Cam.

cylindrical exterior to the nut serves as one of the two ⅜-inch studs, upon which a stop-plate (Fig. 9) rides by means of its slot. The plate is 3½ inches long by ⅞ inch wide, and 3/16 inch thick, and has a slot ⅜ inch wide and 2½ inches long. The second stud (Fig. 10) is tapped into the connecting arm at a distance of 13/16 inch away from the center of the roller axle. This stud is also ⅜ inch diameter where the slot of the stop-plate rides upon it. One end of the stud screws into the arm and has a locknut on the back, and the other end carries a washer and nut to fix the stop-plate in any position it may assume under

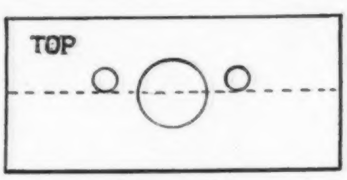


Fig. 13.—Jig.

the guidance of the two studs. The hollowed end of the stop-plate strikes against a loose sliding boss which rides upon the cam-wheel axle and in the slot of the connecting arm, and so prevents the roller from reaching the bottom of the cam. This is the device referred to when mention was made of the rose cutting-frame.

Fig. 11 shows the sliding boss, which is made in two parts. Cast iron is a better material for the main part than gunmetal or brass. Get a circular casting 1 7/16 inches diameter by ¾ inch thick, bore out the ½-inch hole to fit the cam-wheel axle, and turn up on a mandrel to 1 5/16 inches by ⅝ inch. Then file or plane part of the sides away at one end until two

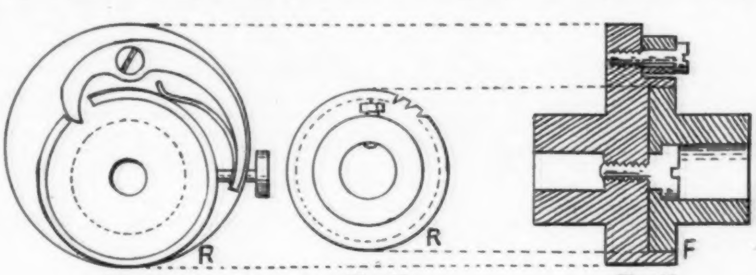


Fig. 14 Fig. 15 Fig. 16.
Adjustable coupling.

shoulders are formed, and the part so reduced will enter and fill the slot in the connecting arm, and slide smoothly from end to end. The hole through the boss will serve as a guide for centralizing the fitting, and a line scored round the boss while in the lathe will give the depth of the shoulders. A gunmetal washer 1 5/16 inch diameter, with a ½-inch hole and 5/32 inch or 3/16 inch thick, should now be screwed to the cast-iron boss by two 3/16-inch countersunk-head screws, one screw being tapped into each end of the boss. It is against the edge of this washer that the stop-plate strikes.

The movement of the sliding boss in the slot of the connecting arm should be greater than 1⅛ inches, and if the reduced part of the iron casting be rounded at the ends this amount of movement will be easily attained. The reason for this requirement lies in the dimensions of the cams, which have a throw—from lowest to highest point—of 1⅛ inches. The central inoperative part of the cam is also 1⅛ inches, and for this reason the boss of the 120-tooth cam-wheel should not exceed this diameter; as otherwise the roller, when at the bottom of the cam, might strike and interfere with the proper motion.

Fig. 17.—Brake.

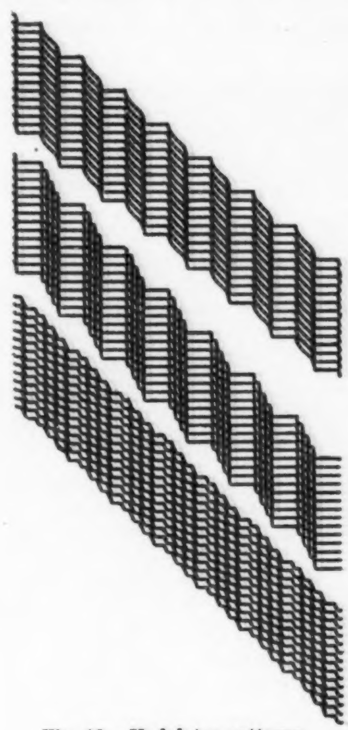


Fig. 18.—Undulator patterns.

At this stage a sketch of one of the cams will be useful. (See Fig. 12.) The cam here shown produces a pattern which may be described as a zigzag with the apices flattened. A simple jig (Fig. 13) for drilling the two screw-holes should be made from a piece of 1¼-inch by ⅛-inch iron or steel plate, 2½ inches long. Bore out a clean hole ⅝ inch diameter to fit the steel sleeve, scribe a line ⅛ inch away from, and parallel to, the diametrical line, and having put the sleeve through the hole, drill two 3/16-inch thoroughfare holes upon the line and just avoiding the collar of the sleeve. To use the jig, bore a ⅝-inch hole through the material for the cam, lay the jig upon it, and put the sleeve through both holes, collar uppermost. Drill one hole first with a twist-drill, insert a well-fitting peg, and then drill the other hole. The jig will be used in the same way for drilling the holes in the boss of the 120-tooth cam-wheel, except that the holes will be marked with a full-sized drill and finished with tapping size. The jig should always be used with the same side upward, and the holes in the cams should be countersunk on the same side on which they were drilled, and then every cam will go in its place without fail.

In designing this apparatus, regard has been had to easing the motions of the cams as much as possible; the wear of the cam is thereby reduced, and a very satisfactory cam can now be made out of ¼-inch white holly, a material easily obtained from fretwood dealers. Metal cams are necessarily superior to wood, and rolled brass ⅛ inch thick and 3 inches to 3½ inches wide, is a handy form of material for the purpose.

Referring again to Fig. 12, a line drawn on the cam will be noticed, and it denotes the two points midway between the bottom and the top of the rise, or the middle point of the motion of the connecting arm. When the roller is upon these midway points, the connecting arm and the radial lever must stand at right-angles to one another, or else the wave will be distorted. This adjustment is attained by moving the cam-wheel axle in the slot of the banjo-plate until the position is found. The banjo-plate is then lowered until the cam-wheel gears with the wheel upon the leading-screw extension shaft, or one of the compounding wheels, as the case

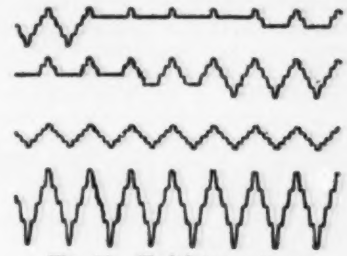


Fig. 19.—Undulator patterns.

may be. Bear in mind any movement of the axle in the slot of the radial lever requires a readjustment to the right-angle central position.

An adjustable coupling has been introduced between the end of the slide-rest screw and the small steel shaft connecting it with the first gear-wheel, as a more certain and convenient means of shifting the wave lengthwise upon the work than the old method of lifting the wheels out of gear while the leading-screw is moved. This coupling is on the ratchet principle, and the wheel is of the same size, but only half the number of teeth of the one inclosed in the boss of the radial lever (Fig. 2). The ratchet is precisely similar. Figs. 14, 15, and 16 show details of the construction of the adjustable coupling.

The dimensions in Fig. 15 are: Ratchet-wheel 1 11/16 inches diameter by 5/16 inch thick, 24 teeth; boss, 1⅛ inches diameter by ¾ inch long. This boss should be bored out to fit upon the socket fixed on the left-hand end of leading screw. Fig. 14 represents the other half of the coupling, and consists of a boss 1 inch diameter by ¾ inch long (boss is shown 1⅛ inches diameter in sketch); a flange 2½ inches diameter by 5/16 inch thick, and which is eccentric to the boss; and a receptacle to carry the ratchet-wheel. This re-

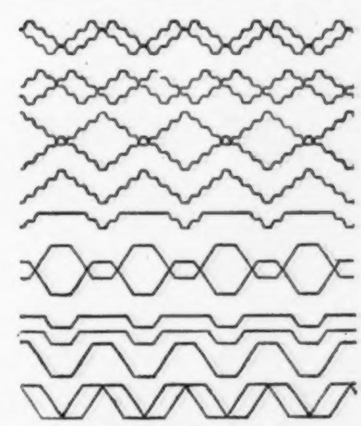


Fig. 20.—Undulator patterns.

ceptacle is concentric with the boss, and has inside measurements of 1 11/16 inches diameter by 5/16 inch deep, and outside 1 15/16 inches by ¾ inch. The eccentricity of the flange is such that its edge just coincides with the outside of the receptacle at one point in its outline. The boss on this side of the coupling is bored out to fit the end of the light steel shaft connecting with the gear-wheels; but this hole should not be bored until the central internal screw shown in section in Fig. 16 has been fitted.

The lengthwise shifting of the wave to elaborate the pattern usually requires a considerable movement of the winch-handle of the leading-screw. Supposing a wave-length of 5 tenths is to be shifted one sixth of its length for the second series of cuts, and again one sixth for a third series, and so on. To do this, slacken the milled-headed screw of the ratchet, hold the eccentric flange, turn the handle of the leading-screw (assumed to be 1/10 inch pitch), and count twenty clicks of the ratchet, i. e.,

$$\frac{5 \times 24}{6} = 20$$

Then tighten the ratchet-screw again. If whole turns of the leading-screw are required, loosen the ratchet-

Fig. 21.—Old reciprocator wave.

Fig. 22.—Old reciprocator wave doubled.

screw, observe the reading of the micrometer upon the leading-screw, hold the eccentric flange, give the requisite number of turns, and fix the ratchet-screw again. Further, if the tail of the ratchet be depressed after the ratchet-screw has been slacked, movements may be made in either direction at will, counting by divisions figured on the side of the ratchet-wheel.

The spiral advance of the single waved line round the cylinder, which has been previously mentioned, involves the use of a brake or friction-pad to steady and control the movement of the lathe mandrel. This brake is carried in the socket of the dividing index, and is shown in Fig. 17. The pad or brake bears upon the flat surface of the division plate, which is not hurt in the slightest by its use. A taper fitting, reduced at the smaller end to carry a washer and a small wing-nut, is made to the socket. The larger end, nearest the division plate, is turned down, and a piece of strong clock-spring, about 3/8 inch wide and 3¼ inches long, is riveted on with a washer under the head of the rivet to support the spring. About ¼ inch of the upper end of the spring is bent over at right-angles toward the division plate, this end being softened before bending. The spring and taper fitting are then put in place and screwed up with the wing-nut. A block of wood about 1¼ inches square is then made, rather thicker than will fill the space between the spring and the division plate, and is fixed to the spring close under the bent end. Two short wood screws 3/8 inch long will suffice to hold it. The block and spring are then tried in place, together with a piece of new "boot-upper" leather the size of the block. It will probably be found that the wood block requires tapering down in thickness to make it fit the division-plate. The leather is then fixed to the wooden block with "Prout's elastic glue," an invaluable compound, and four wooden boot-pegs are driven through the leather and into the wooden block, to make all secure. The leather should then be greased.

When the brake is in place the lathe-pulley should move stiffly if pulled round with one finger and thumb. All that is required is that the revolving drill shall not have power to move the work while the mandrel is controlled by the brake alone. There are really three points to consider when the advancing spiral wave is being made: First, the resistance of the brake; second, the power of the spring under the ratchet tail, and this should be only strong enough to make the point of the ratchet sure of bottoming in the tooth of the wheel; and, third, the power of the spiral spring which provides the return motion, and this may be fairly strong. A suitable spring is made of 17 B.W.G. hard-drawn steel wire, barrel ½ inch, length over all, about 5¾ inches. This spring requires a pull of 6 pounds to extend it to 6½ inches.

The spiral produced is necessarily of an interrupted character, the rising half of the cam causing the advance, while during the falling half the mandrel is at rest; for the ratchet being left quite free to work uncontrolled by the milled-headed screw, and the mandrel being held by the brake, the radial lever returns to its first position without moving the work, and then rises again and causes a further advance. The effect upon the work is that one half the wave is followed by a straight line, which is, in turn, followed by another half-wave, and so on.

With reference to the sketches accompanying this paper, some of the figures are lettered *F*, *R*, and *L*. These letters denote the position in which the parts stand when seen from the front of the lathe. *F* = front, *R* = right side, *L* = left side.

A few specimens drawn by the apparatus are given, just to show the kind of patterns obtainable, the selection being made to show how completely they differ from the patterns produced by the older apparatus. Figs. 18, 19, and 20, Undulator; Fig. 21, Old Reciprocator Wave; Fig. 22, Ditto doubled.

Mathematics for Recreation

By F. B. Selkin

*[The reader, after perusing the arguments presented below, may perhaps at first find his faith in the logical security of mathematical reasoning shaken. It will be a good exercise for his critical judgment to seek to discover the fallacy involved in the arguments given.—*Ed.*]*

1. Theorem. Any number is equal to any other number, or, all numbers are equal to one another.

Let a and b be any two numbers, and let c be their difference.

Then $a-b=c$

Multiplying both members by $a-b$,

$$a^2-2ab+b^2=ca-cb,$$

whence $a(a-b-c)=b(a-b-c)$.

Therefore $a=b$.

In other words, any two numbers are always equal.

2. Theorem. Any two unequal numbers are always equal.

Let a and b be two unequal numbers, and let c be their arithmetical mean.

Then $a+b=2c$.

Therefore $(a+b)\ (a-b)=2c\ (a-b)$.

Therefore $a^2-2ac=b^2-2bc$,

and $a^2-2ac+c^2=b^2-2bc+c^2$.

or $(a-c)^2=(b-c)^2$.

Hence $a-c=b-c$

and $a=b$.

But a and b were taken as unequal. Hence any two unequal numbers are always equal.

SPECIAL CASES.

1. To show that 1 equals 2.

Let $a=b$.

Then $ab=a^2$.

Hence $ab-b^2=a^2-b^2$.

and $b(a-b)=(a+b)\ (a-b)$.

Therefore $b=a+b$,

or $b=2b$,

and $1=2$.

2. To show that 2 equals 3, 5 equals 7, and 9 equals 5.

By a somewhat similar reasoning we can show that 2 equals 3.

For $2^2-2\times\frac{5}{2}\times2=3^2-2\times3\times\frac{5}{2}$

Completing the squares by adding $(\frac{5}{2})^2$, or $\frac{25}{4}$, to each member we have:

$$(2-\tfrac{5}{2})^2=(3-\tfrac{5}{2})^2,$$

whence $2-\frac{5}{2}=3-\frac{5}{2}$,

and $2=3$.

To prove that 5 equals 7:

Let $a=\frac{3}{2}b$,

Therefore, $4a=6b$,

or $14a-10a=21b-15b$,

and $15b-10a=21b-14a$,

or $5\ (3b-2a)=7\ (3b-2a)$

Hence $5=7$.

We can also show that 9 equals 5.

For, $9+5=2\times7$

Multiplying both members by $9-5$, we have:

$$9^2-5^2=2\times7\times9-2\times7\times5.$$

Therefore, $9^2-2\times9\times7=5^2-2\times5\times7$.

Adding 7^2 to both members,

$$9^2-2\times9\times7+7^2=5^2-2\times5\times7+7^2,$$

or, by taking the square root, $9-7=5-7$.

Hence $9=5$.

3. To show that -1 equals $+1$.

Furthermore, $+1$ equals -1.

For, $\sqrt{a}\times\sqrt{b}=\sqrt{ab}$,

whence $\sqrt{-1}\times\sqrt{-1}=\sqrt{(-1)\ (-1)}$,

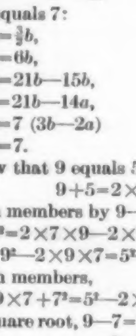
or $(\sqrt{-1})^2=\sqrt{1}$,

whence $-1=\ 1$.

* Reproduced from the Teachers' College *Record*.

Distribution of Sugar in the Beet Root

The distribution of sugar and non-sugar substances in the beet root has considerable importance, both from the point of view of vegetable physiology and of sampling for commercial purposes. Some work has already been done in this direction, but in the opinion of Messrs. Floderer and Herke, quoted in *Knowledge*, its accuracy is open to question, owing to the defective methods of dividing the roots for the analysis. Accordingly, they have made a fresh investigation, using for the purpose fifty roots of uniform size, which they divided into ten transverse sections and sub-divided into concentric rings in the manner shown in the diagram. The respective corresponding pieces from each of the roots were mixed together so that in all nineteen separate lots were obtained for the analysis.



A diagram illustrating the distribution of sugar in the beet root.

The results showed that the sugar (sucrose) was present in the greatest proportion in the innermost portion of the root, those sections between the middle axis and the part where the root began to taper being the richest. Thus the most sugar was found in the following sections: 14, 15, 19, 13, 12, 18, 17 and 16; and then in decreasing quantities in 11, 6, 8, 5, 4, 3, 7, 9, 2, 10 and 1. Whence it appears that the body of the root is richest in sugar and the crown the poorest.

With regard to the other constituents it was found that the total solid substances varied but little in any part of the root, with the result that a rise in the proportion of sugar was accompanied by a decrease in the amount of non-sugar substances. In fresh beet roots the proportion of soluble nitrogenous bodies was lower in the interior parts, while the mineral constituents (ash) varied inversely with the amount of sugar. A decrease in the amounts of potash and magnesia was observed on proceeding from 1 down to 15, where the sugar was present in greatest proportion, after which both substances increased with the fall in the sugar. It was not possible, however, to establish any relationship between the amounts of sugar and phosphoric acid.

Italy to Adopt Gasolene Haulage.—As one result of the experience of the Italian War Office in the Tripoline campaign in Africa, it has been decided to adopt on a large scale motor haulage, in lieu of horses, for heavy artillery. Foreign, as well as Italian, manufacturers are invited to tender for contracts which cover from 70 to 80 suitable vehicles.

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